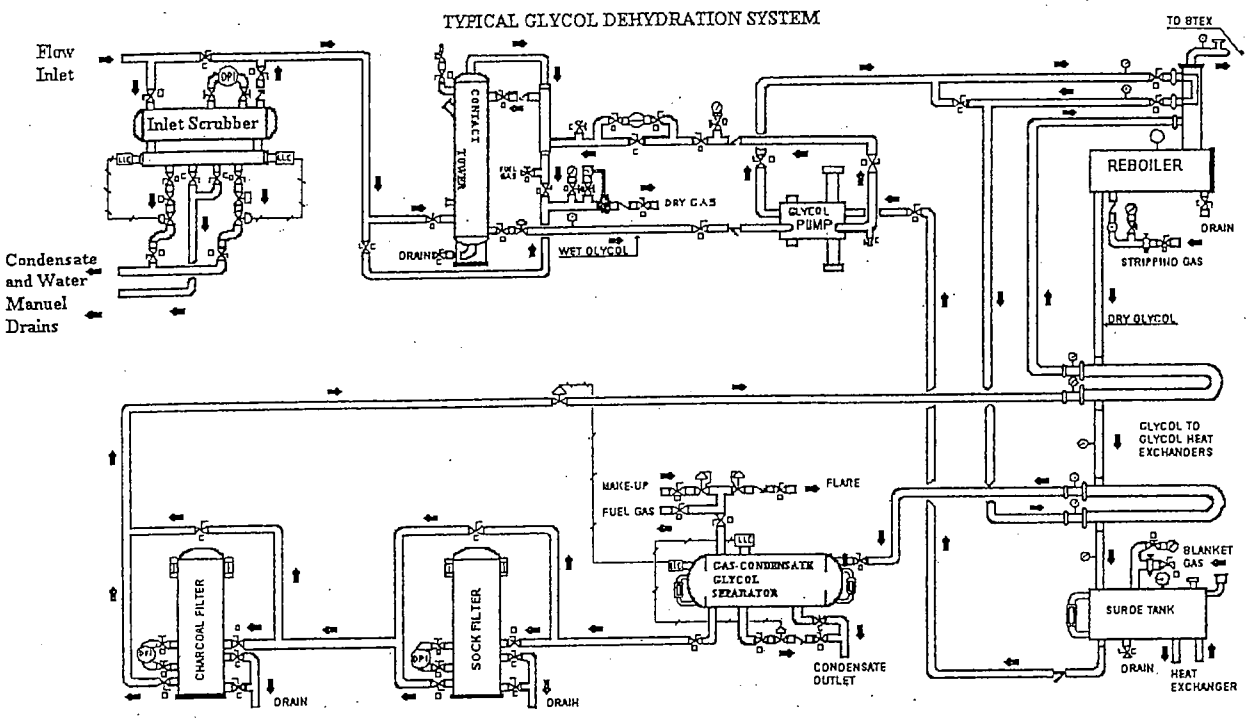
GLYCOL



DEHYDRATION

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Glycol Dehydration

Unit I

Principles & Operation of Glycol Dehydration

WATER CONTENT OF NATURAL GAS

All produced natural gas contains water. Some of this water is free, in a liquid form and may be removed by passing the gas through a separator or scrubber. After passing the gas through the separator removing the free water, the gas will still contain water in a vapor phase. The capacity to hold water is a function of the gas composition itself, but is also affected by the pressure and temperature of the gas. (See appendix "A").

When gas has absorbed the limit of its water holding capacity for a specific pressure and temperature it is said to be saturated. Up to that point, it is undersaturated. Any additional water added at the saturation point will not vaporize, but will fall out as free liquid. Also, at this point, if the pressure is increased and/or the temperature decreased, the capacity of the gas to hold water will diminish, and some of the water vapor will condense and drop out.

This point is known as the dew point and can best be illustrated by morning dew which is a result of atmospheric air being cooled during the night. In other words, the dew point is the temperature at which water vapor in natural gas condenses into a liquid. That temperature, in conjunction with pressure, is used as a means of measuring the water vapor content of natural gas. As water vapor is removed from natural gas the dew point lowers. The difference between the original dew point and the dew point achieved after some of the water vapor is removed, is called the dew point depression. Dew point depression can be used to describe the amount of water needed to be removed from the natural gas to establish a specific water vapor content.

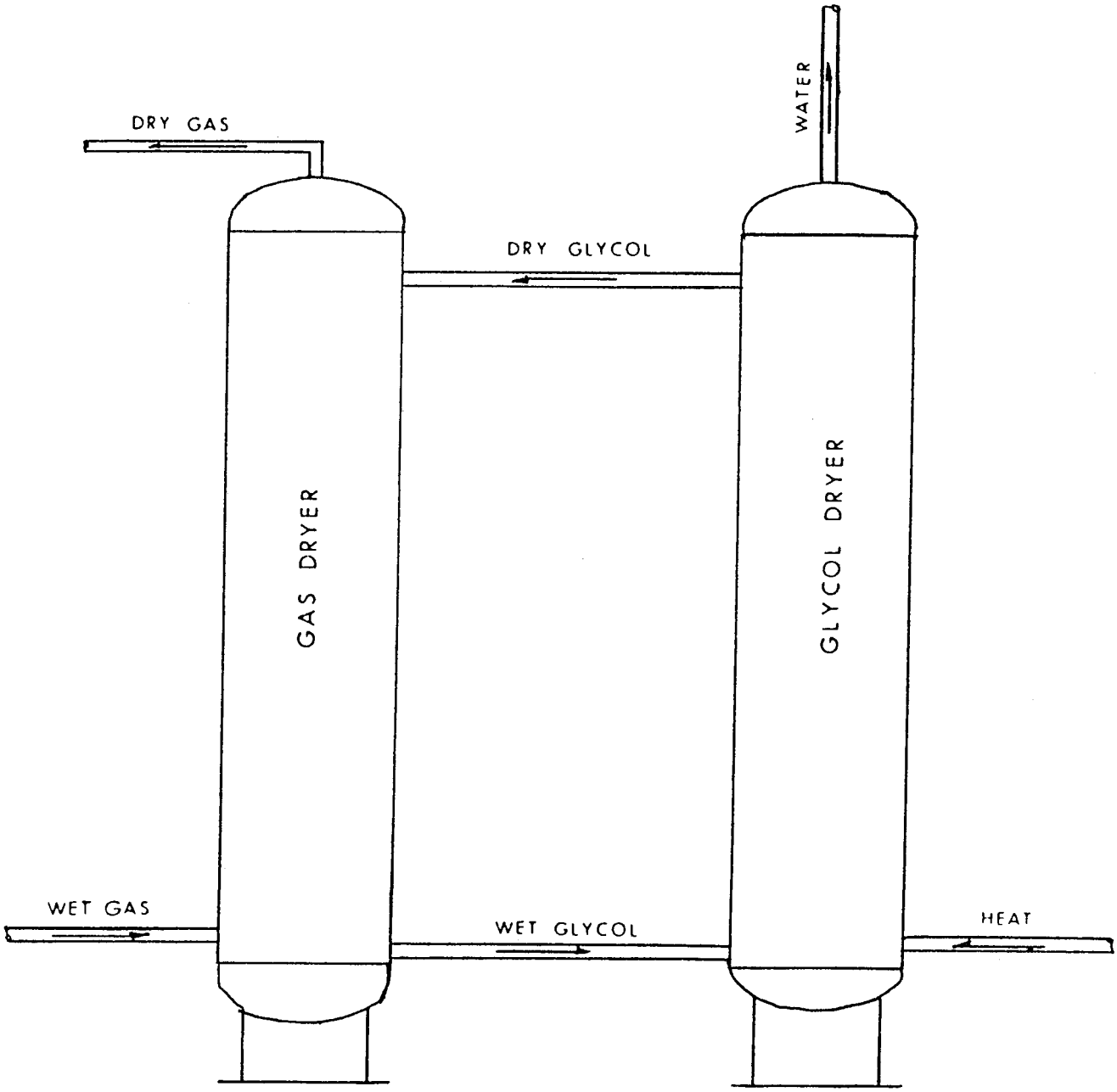
The term "dew point" is somwhat ambiguous in the oil patch. Rather than a temperature, dew point, to many, simply means the amount of water in natural gas. In this text, for simplicity, when dew point is mentioned, it is the quantity of water in the gas that will be referred to, rather than the temperature at which condensation takes place.

WHY DEHYDRATE?

The term dehydration means removing water from a substance. Water vapor is removed from natural gas by means of the glycol absorption process. The glycol absorbs the water from the gas, then the water is distilled from the glycol and driven off into the air.

If water vapor is allowed to remain in the natural gas it will reduce the efficiency of a pipeline. The water will collect on the wall and in low places of pipelines and fittings, thereby reducing pipeline capacity. The water will cause corrosion. Water and other corrosive agents will in time eat holes in the pipe or vessels through which the gas passes. The water vapor mixed with hydrocarbons will form hydrates or ice blocks in pipes, valves or vessels. Hydrates will form at fairly high temperatures when gas is under pressure, and they will completely plug up a gas sales line. Hydrates can form at 50 to 70 degrees Fahrenheit in 1000 psig lines. (See appendix "A").

SIMPLE GAS/GLYCOL DRYING PROCESS



Most natural gas is sold to gas transmission companies by contract agreement. These contracts specify the maximum water content in the gas that is acceptable by the gas transmission companies. This value of water content is generally 5 to 7 pounds of water per million standard cubic feet of gas. Usually, the transmission company will take a dew point approximately once a month to insure that only gas with the allowable water content will flow into their pipeline.

PRINCIPLES OF DEHYDRATION

After the free water has been removed from the gas with separators, 25 to 100 pounds of water vapor per MMSCF of gas will remain, depending on the temperature and pressure of the gas. The warmer the gas and the lower the pressure, the more water vapor it will contain. Somewhere between 20 to 95 pounds of water per MMSCF of gas must be removed before the dew point requirements of the gas transmission companies will be met.

There are several methods of dehydrating the gas but this text will be concerned with the glycol regenerative type dehydration system, using triethlylene glycol (See appendix "B"). Triethylene glycol is a liquid desiccant. (A desiccant is a substance that attracts and retains water). For simplicity, refer to triethylene glycol as glycol.

A means of bringing the glycol in contact with the natural gas is necessary so it will remove the particles of water from the gas. This is done in a vessel called a contactor, which is designed in such a way that the gas must bubble through trays filled with liquid glycol. The process of removing the water from the gas by the glycol is called absorption. This is similar to the way that a blotter will pick up ink.

Glycol is very expensive. If it were used only one time and then discarded, the cost of this method of dehydration would be prohibitive. So, when the glycol has become saturated with water, it flows to another vessel called a reboiler to cook out the water so that the glycol may be re-used. The process for removing the water from the glycol is called distillation. Water boils at 212 degrees Fahrenheit, whereas glycol has a boiling point of 546 degrees Fahrenheit. This makes purifying the glycol fairly simple. By heating the wet glycol to a temperature somewhere below the boiling point of glycol and above the boiling point of water, the water will be cooked out.

Absorption of water from the gas in a contactor and distillation of the water from the glycol in a reboiler are the basic principles of the glycol regenerative dehydration system, but there are other vessels and equipment involved for improving efficiency and moving the glycol.

THE VESSELS AND FLOW

The wet gas - that is, the gas to be dehydrated, passes first through a separator to remove the free water. After passing through the separator, the gas then enters the contactor near the bottom of the vessel. Inside the contactor there are several trays with weirs, or dams,

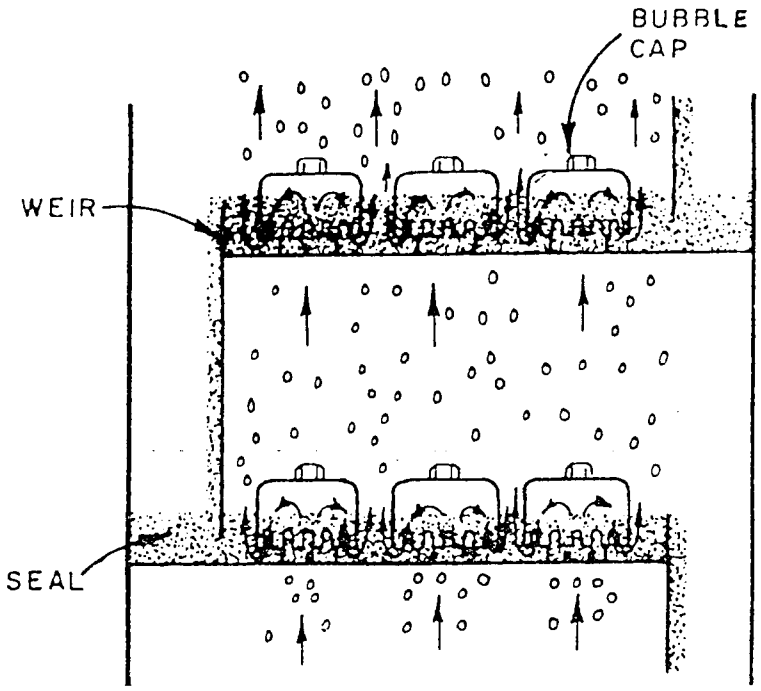


FIG 1

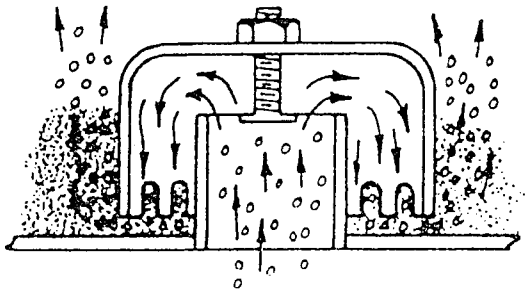
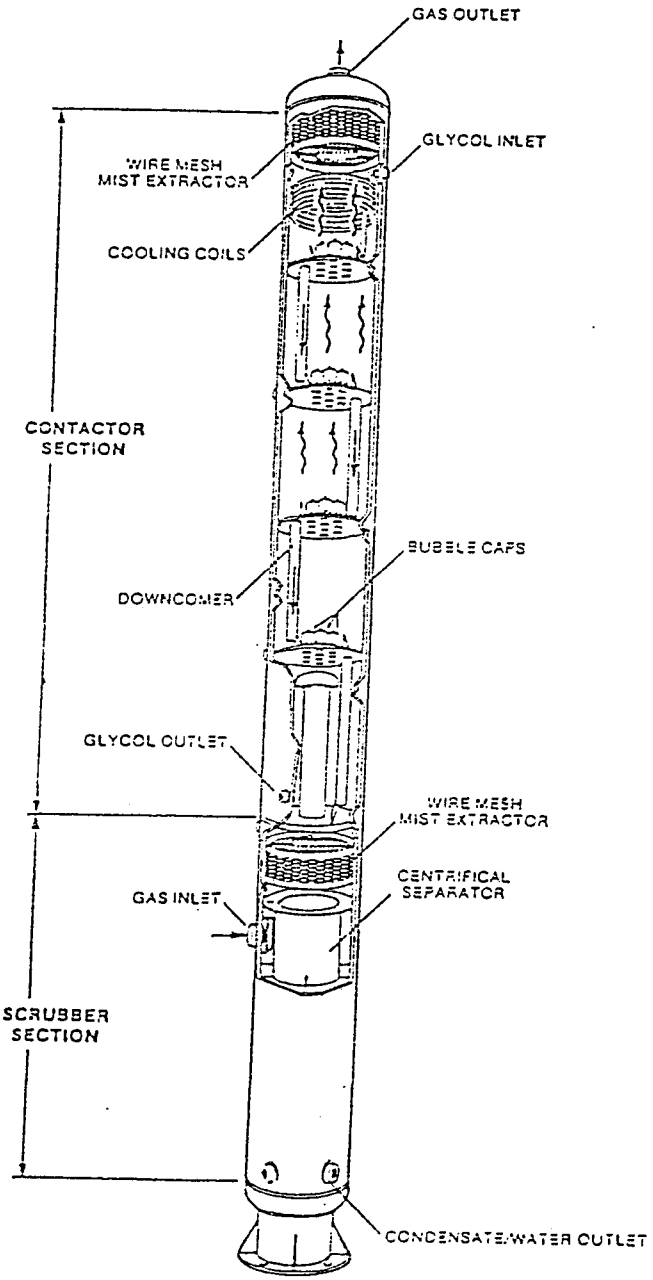
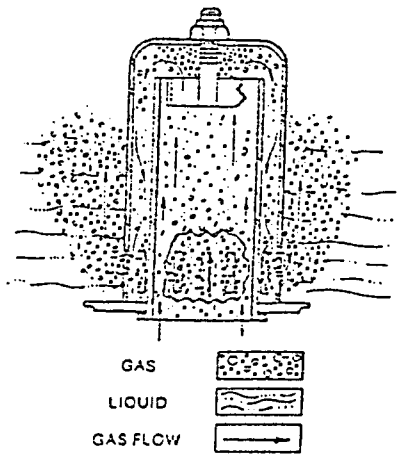


FIG 2

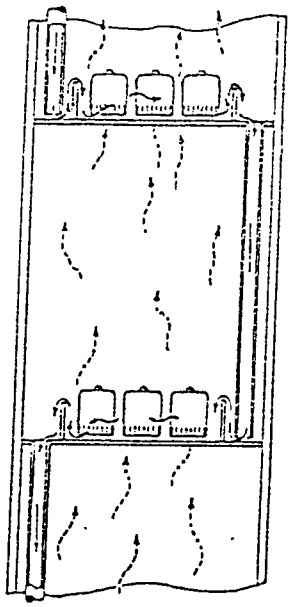
to hold a level of glycol, so the gas must bubble through the glycol solution as the gas flows upward. Each tray has a number of openings, evenly arranged, with bubble caps bolted over them. The gas, traveling upward in the contactor, is forced to pass through these caps and bubble through the glycol. This is where the gas gives up the water vapor to the glycol. As it passes upward through each succeeding tray, the gas becomes drier. Before leaving the contactor, the gas passes through a mist extractor to remove glycol that may be trying to leave with the gas. As the glycol particles collect and become heavier in the mist extractor, they will drop back into the tray and rejoin the glycol stream. The gas then leaves the contactor and passes through a heat exchanger, where it cools dry glycol before it enters the tower. A heat exchanger does just what its name implies, one fluid stream exchanges heat with another. Usually one stream is passing through tubes surrounded by another flowing stream between the tubes and the outer jacket. On a few installations, the dry gas will pass through another vessel called a glycol knockout. The purpose of this vessel is to recover any glycol which has

GLYCOL CONTACTOR TOWER WITH SCRUBBER SECTION

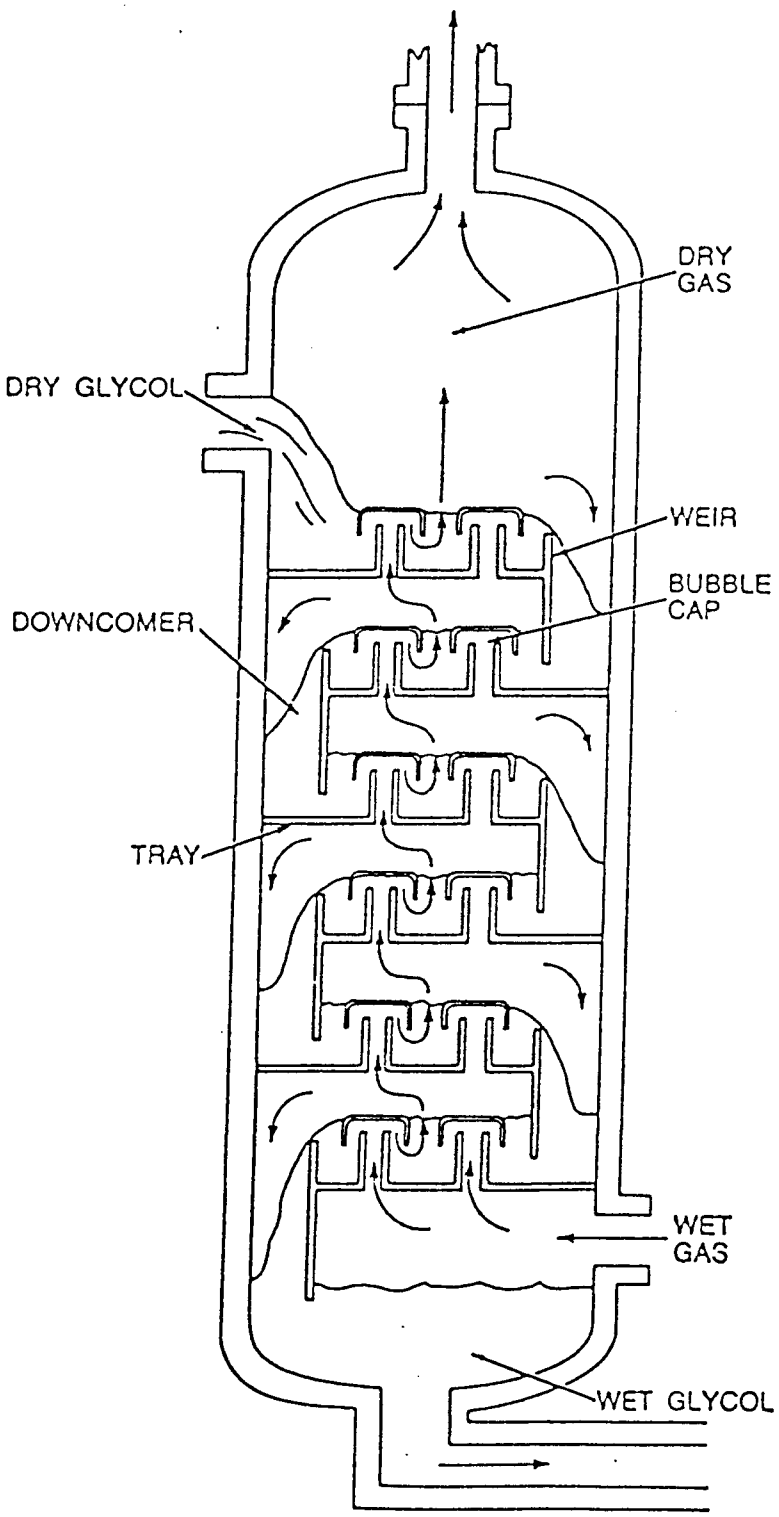




BUBBLE CAP DURING OPERATION



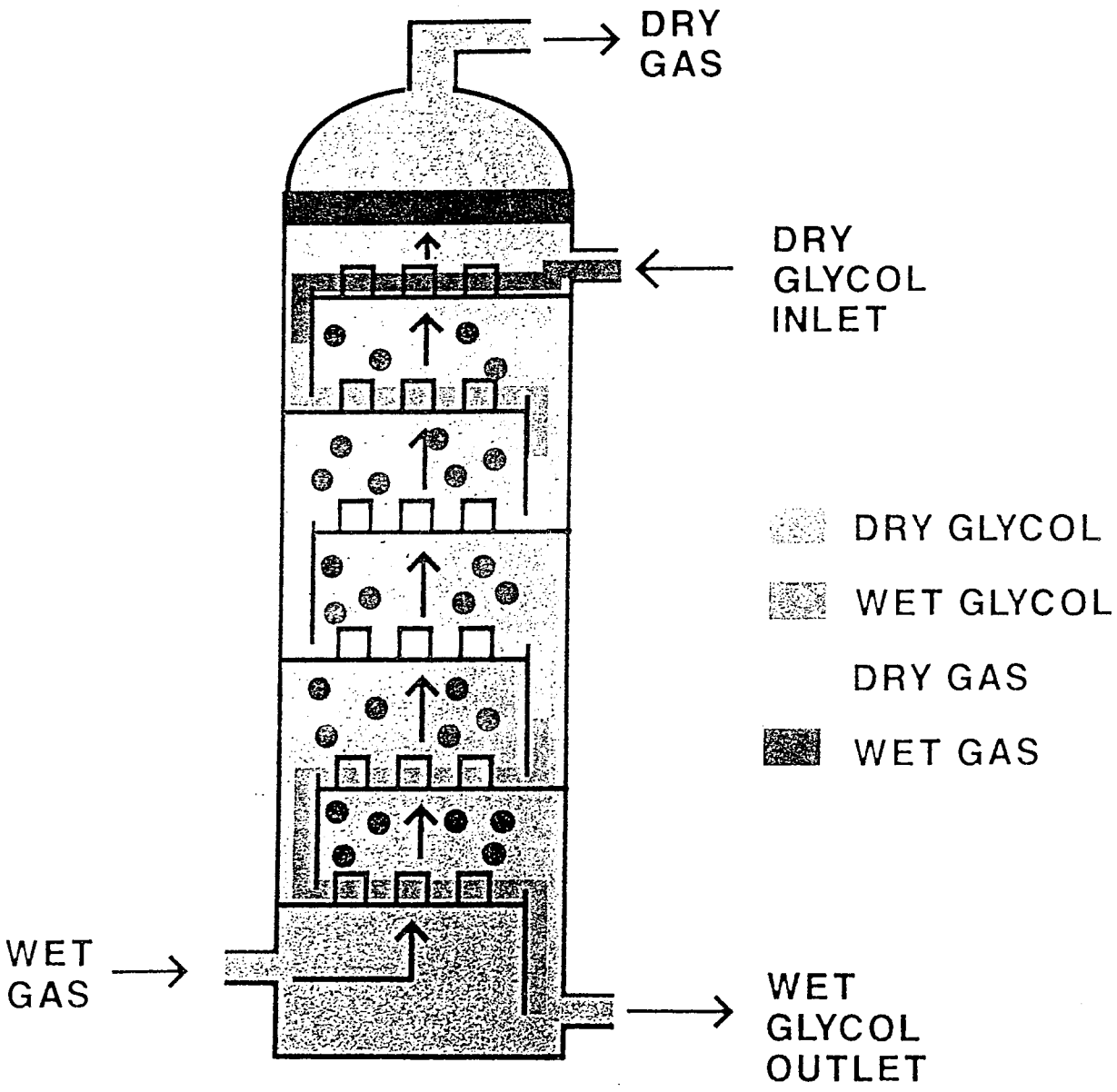
FLOW DIAGRAM

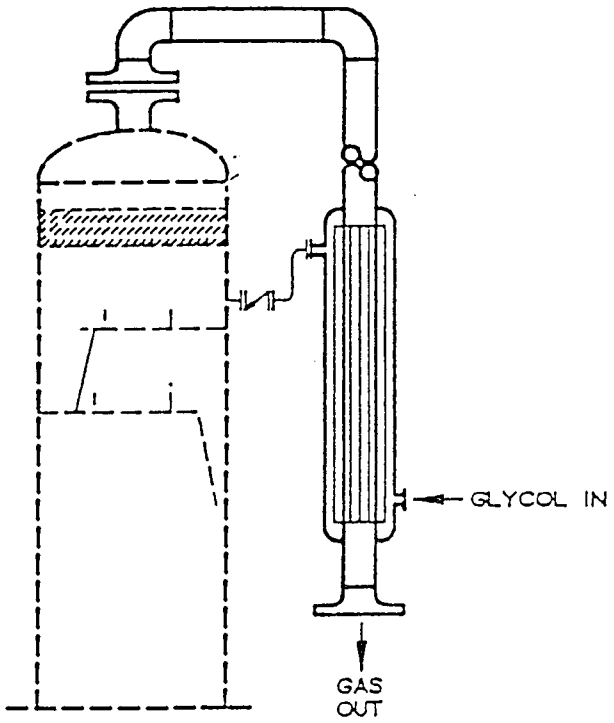


TRAYS WITH BUBBLE CAPS

FIG. 3

CONTACTOR



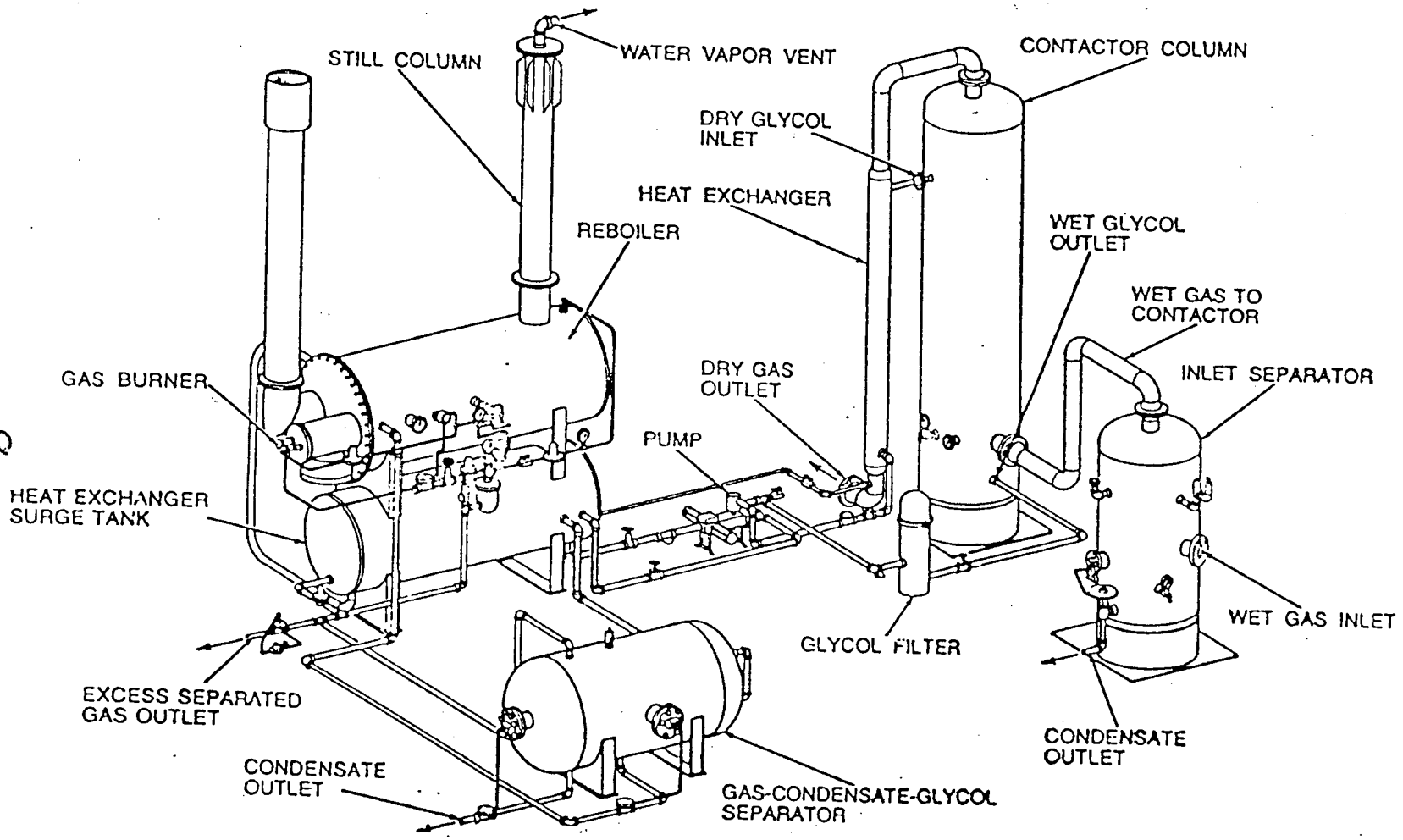


GLYCOL-GAS HEAT EXCHANGER

FIG 4

escaped with the gas through the mist extractor. After the gas has gone through the contactor and possibly a glycol knockout, it is ready for use as fuel and sales to the gas transmission companies.

The glycol makes a circular path through the system. Dry glycol (water free glycol) regenerated by the reboiler gravitates through heat exchangers. The hot, dry glycol is cooled by the cooler wet glycol on its way from the contactor to the reboiler. From the heat exchangers the cooled dry glycol then gravitates into a lower vessel called a storage, or surge, tank. Occasionally the surge tank will be an integral part of the reboiler rather then a separate vessel. In this case the heat exchangers would be downstream of the surge tank. From the storage tank or possibly the heat exchangers the dry glycol passes through a strainer, then goes to the pumps. The strainer removes solid and abrasive particles that might



GLYCOL DEHYDRATION UNIT

TYPICAL FLOW PATTERN

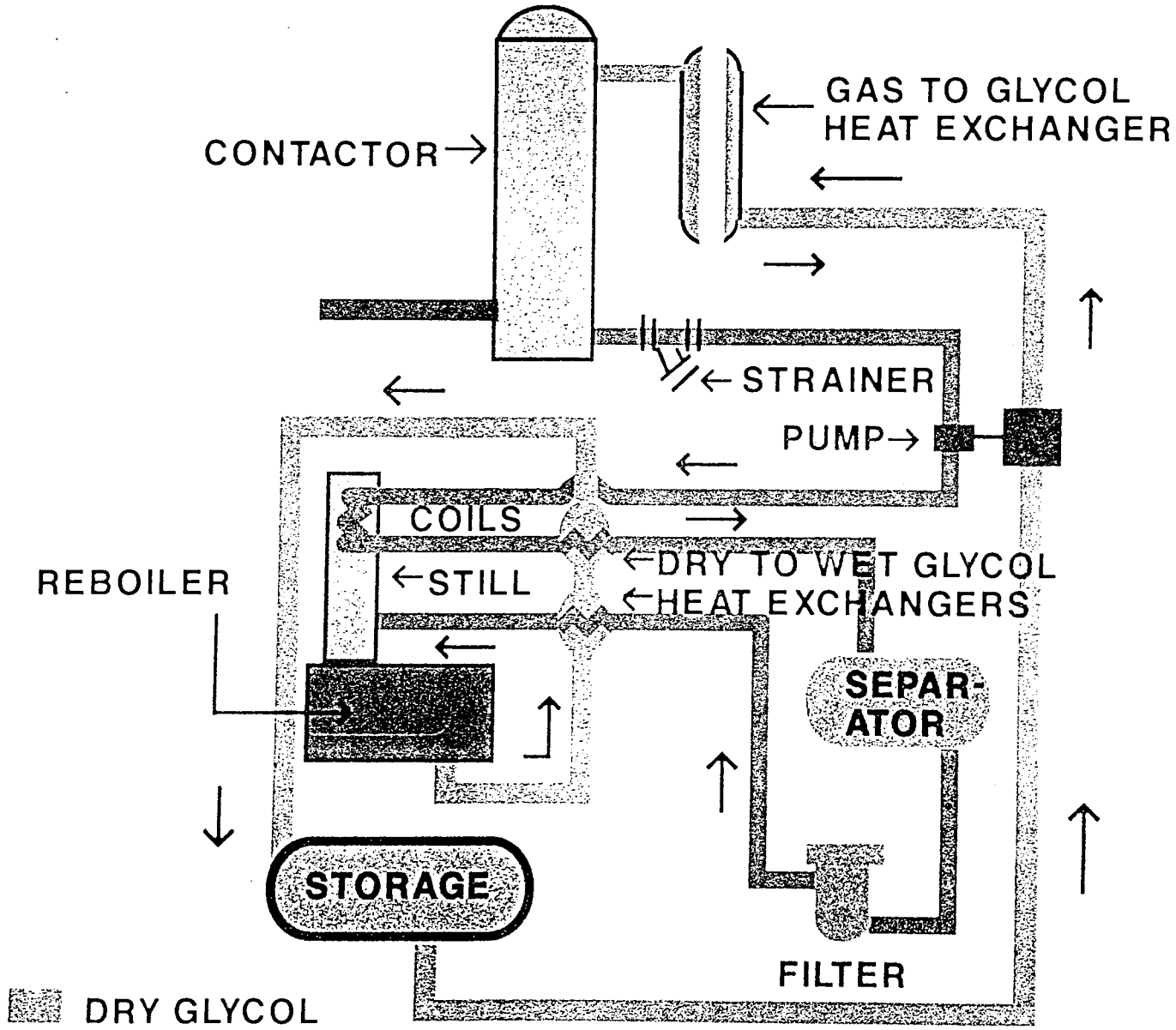
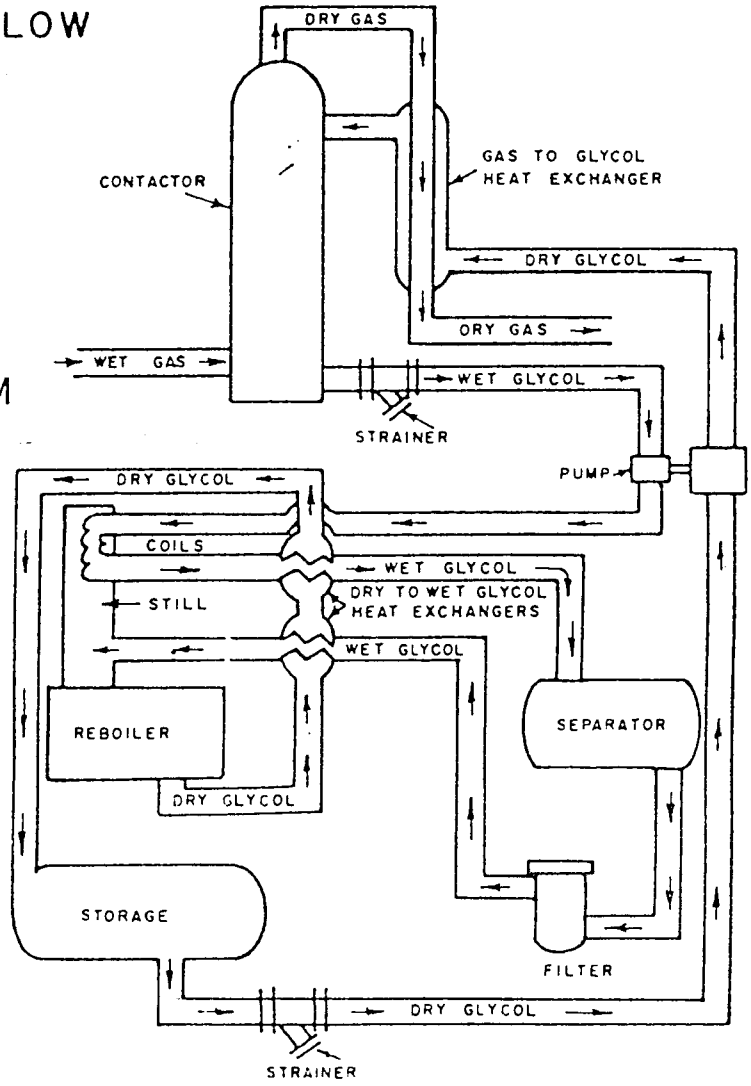


FIG 5

TYPICAL FLOW

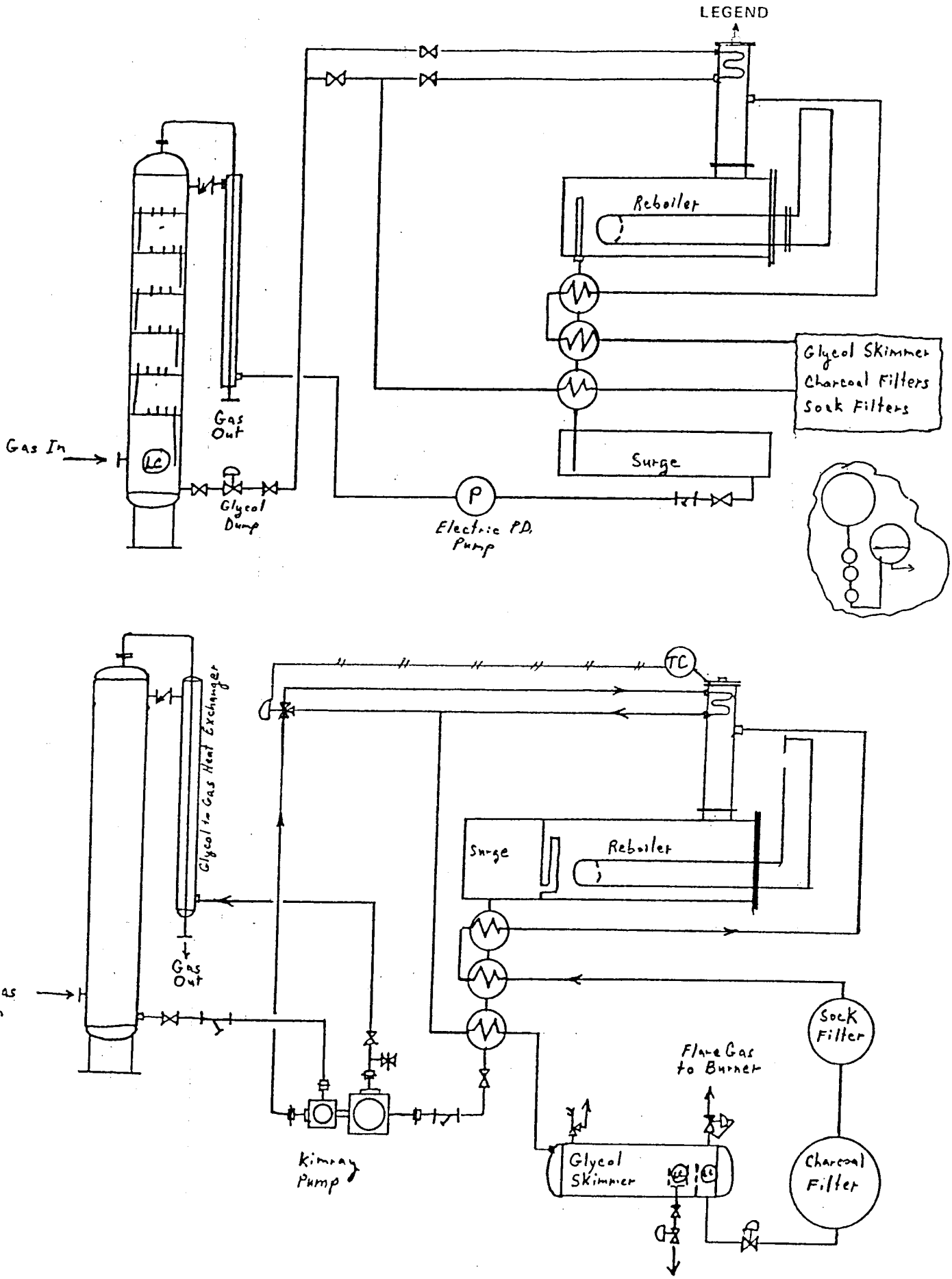
PATTERN

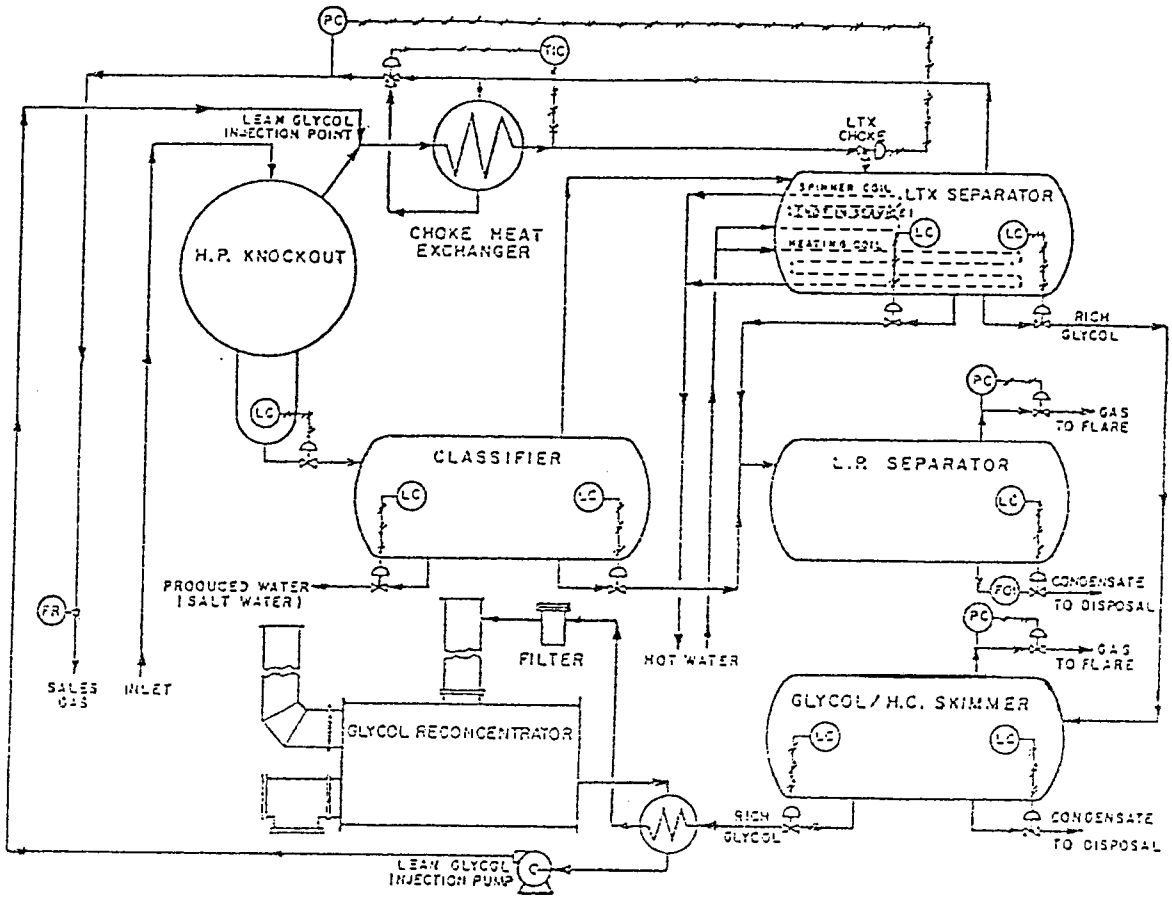
EXERCISE:
COLOR KEY
THE DIAGRAM



damage the pumps. The dry glycol is pumped up to contactor pressure, then passes through the gas-glycol heat exchanger before entering the contactor tower. This heat exchanger cools the glycol near the temperature of the gas before the glycol enters the contactor. It is important that the glycol be near the gas temperature to prevent foaming. The dry glycol then enters the contactor tower and flows across the top tray. This is the first contact between glycol and gas.

A level of glycol is maintained in the tray by means of a weir. This level is above the slots in the bubble caps, so the gas is forced to bubble through the glycol. The glycol flows over the weir, through a downcomer and into the tray below. The downcomer seals the glycol passage into the tray below to prevent gas from short-circuiting past the bubble caps. As the glycol spills downward through each succeeding tray, it becomes wetter with the water it has absorbed from the gas and collects in the bottom of the contactor saturated with water. On the other hand, as the gas moves upward through each succeeding tray, it becomes drier. The

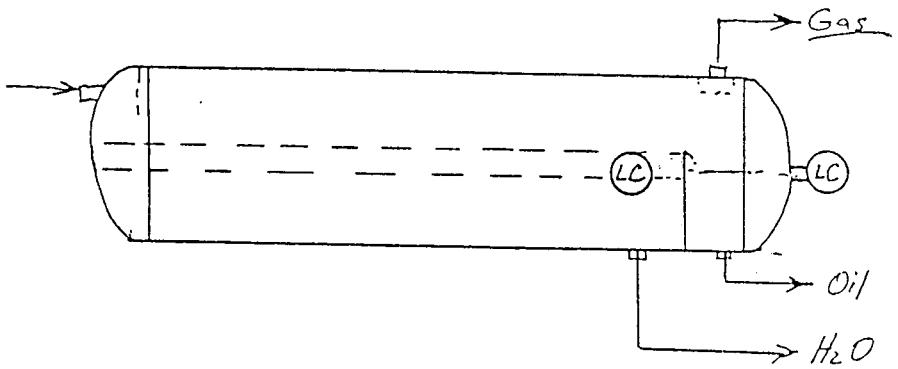

LEGEND
Reboiler
Glycol Skimmer
Charcoal Filters
Sock Filters
Surge
Gas Out
Gas In
LC
Glycol Dump
P
Electric P.D. Pump
TC
Glycol to Gas Heat Exchanger
Gas Out
Gas In
Surge
Reboiler
Sock Filter
Flare Gas to Burner
Kimray Pump
Glycol Skimmer
LC
LC
Charcoal Filter

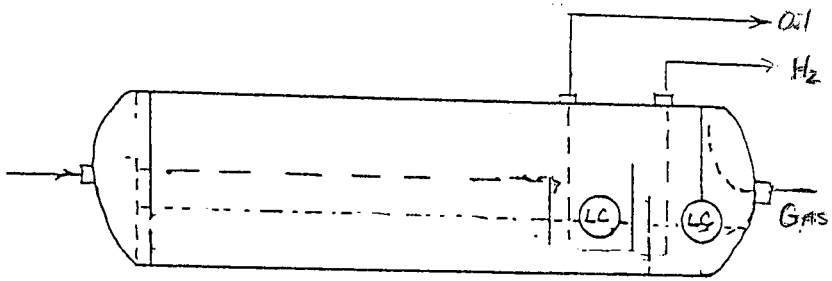


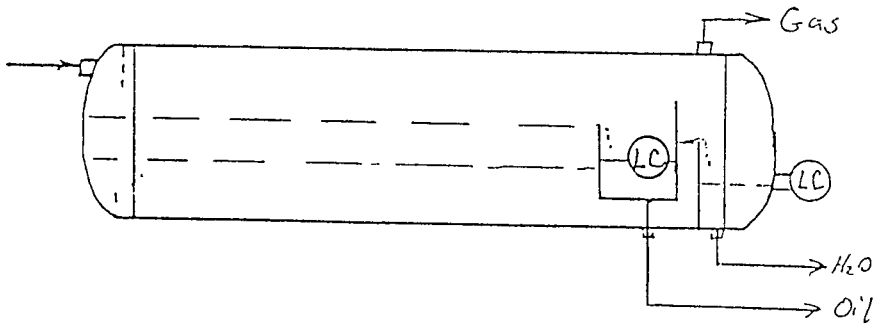
SIMPLIFIED FLOW SCHEME
LOW TEMPERATURE SEPARATOR (LTG)

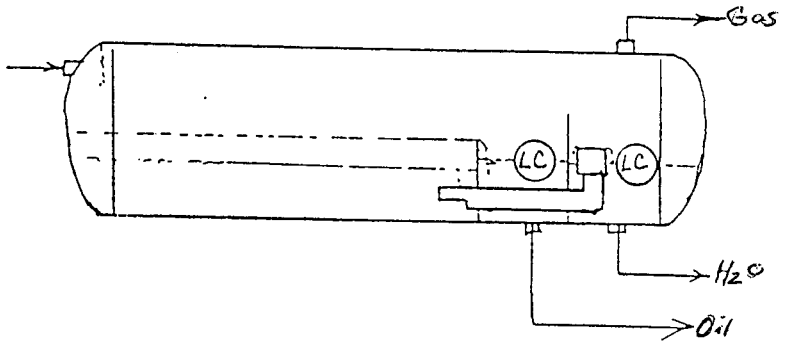
FIGURE 7

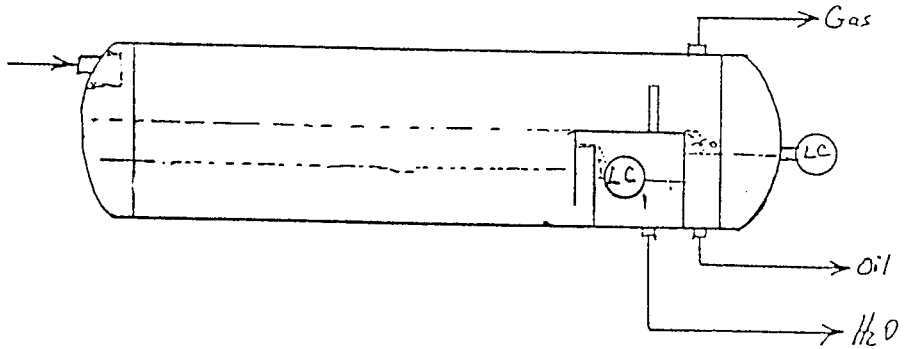
Horizontal 3 Ø Separators

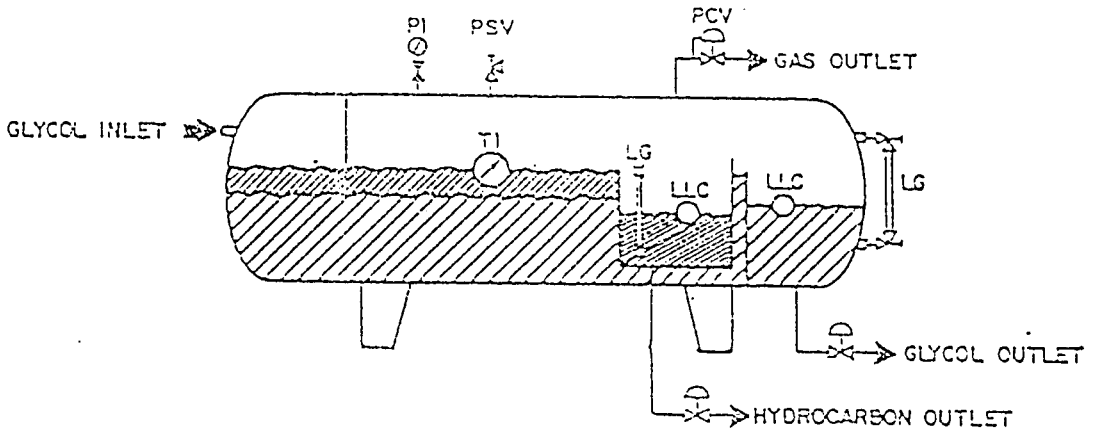












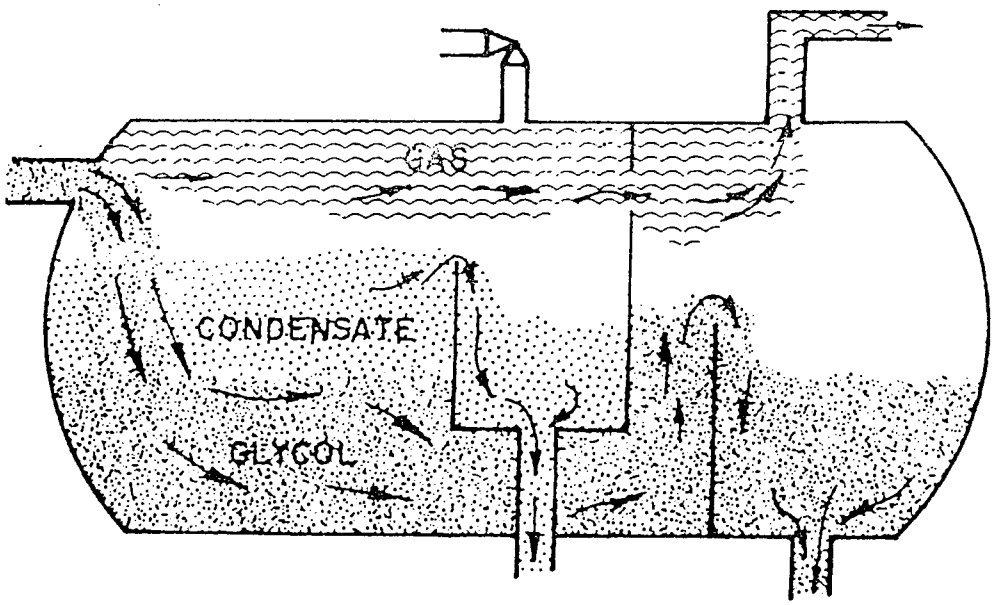
GLYCOL HYDROCARBON SKIMMER *

wet glycol that has accumulated in the bottom of the vessel passes through another strainer, to remove abrasive particles before entering the pump. On installations using Kimray Pumps, the wet glycol at contactor pressure, along with a small amount of gas is used to power the pump. It is the gas that gives the wet, high pressure glycol enough energy to pump the dry, low pressure glycol up to contactor pressure. This type pump will be used for our typical flow plan. Other systems, using another type pump, will be brought up later in this presentation.

The cool wet glycol takes a pressure drop across the pump and then passes through a coil in the top of the reboiler still column. This coil cools the vapors leaving the still and condenses the glycol vapors to liquid. The glycol liquid droplets gravitate back down the still column into the reboiler. The water remains as a vapor and continues on out the top of the still column. This cooling coil is generally called the reflux coil.

The wet glycol from the reflux coil in the still has been warmed slightly, then it passes through one phase of the dry glycol to wet glycol heat exchangers. The hot dry glycol from the reboiler heats the wet glycol further and, in turn, cools the dry glycol before it goes to the storage tank.

The heated glycol leaves this heat exchanger and now enters the gas-condensate-glycol separator. The heat it has just picked up aids in the separation that takes place in this vessel.



GAS–GLYCOL–CONDENSATE SEPARATOR

The purpose of this vessel is to remove the gas and condensate hydrocarbons that were picked up by the glycol on its path through the contactor. Some heat will cause the hydrocarbons to come out of solution from the wet glycol. The hydrocarbon condensate is skimmed off the glycol in this vessel, and gas vapors will leave from the top.

The wet glycol then leaves the gas-condensate-glycol separator and passes through a sock type filter. This filter removes solids, tarry hydrocarbons and other impurities. From the sock filter the glycol then enters a carbon filter. Activated carbon granuals in this filter adsorb liquid entrained hydrocarbons, well treating chemicals, and other impurities from the glycol.

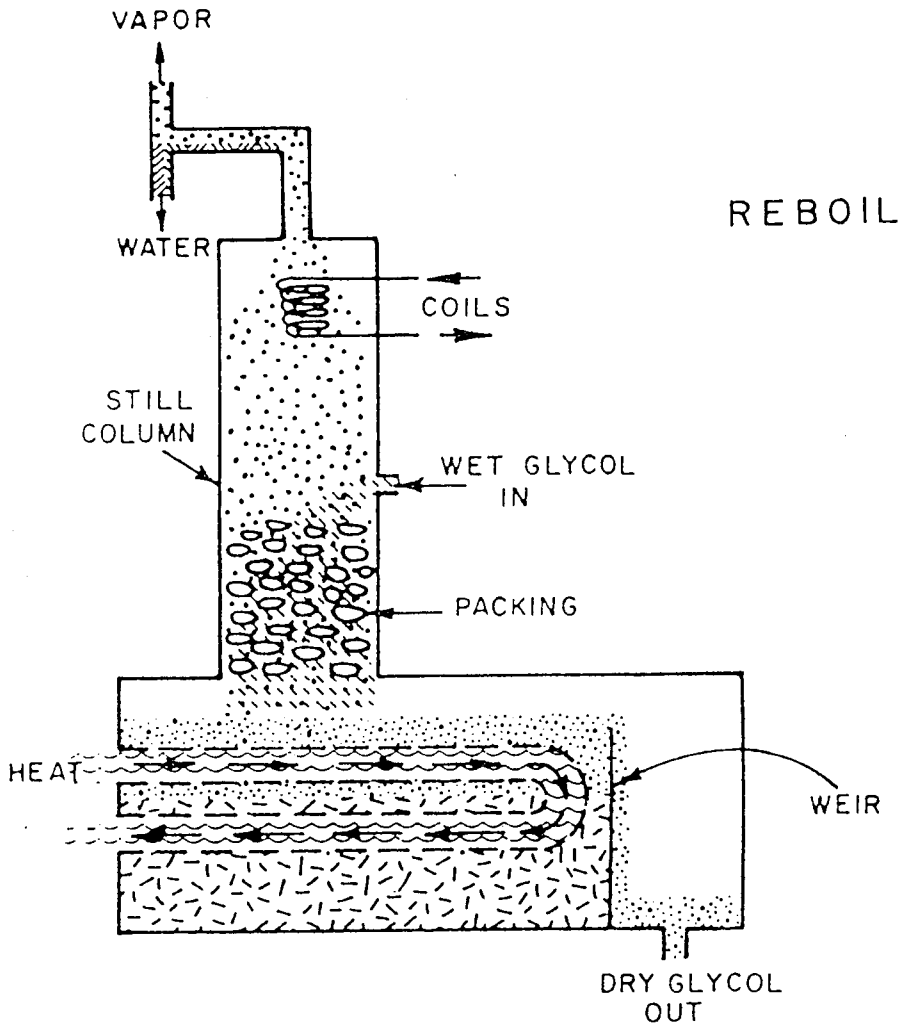


FIG 7

From the filter, the wet glycol then flows through the second dry glycol to wet glycol heat exchanger. This preheats the wet glycol as much as possible before entering the reboiler. You can see now that heat exchangers greatly increase the efficiency of a process by reducing the amount of outside heat required in the reboiler.

From this heat exchanger, the wet glycol enters the still column of the reboiler. Inside the reboiler still column is a section filled with ceramic or stainless steel saddles. This is called a packed column. The glycol spreads out uniformly over these ceramic saddles and drips down through the packed section. The distillation, or cooking process, is started in this section to drive out the water as a vapor from the glycol. In some cases as much as 75% to 80% of the water contained in the glycol can be removed in the still column before the glycol reaches the reboiler.

Occasionally, the glycol enters the reboiler below the packed column. Distillation then occurs in the reboiler. This type of column is called a reflux condenser and will be discussed more fully later in this text.

From this packed column, the wet glycol drops downward into the bottom of the reboiler. A source of heat is circulated through a tube in the lower section of the reboiler to heat the glycol solution up to 350 to 400 degrees Fahrenheit, which is below the boiling point of triethylene glycol. Generally, offshore, waste heat from compressor or generator exhaust gasses is used for the reboiler heat source, but many installations also use a gas fired heater. The temperature of the glycol in the reboiler is critical and is controlled at this point.

The water cooks out of the glycol solution and moves upward through the still column as steam. Some glycol vapors also are mixed with the steam. As the mixture passes the cool reflux coils in the top, the glycol vapors are condensed and drop back down. Then the water leaves the top as steam. Some of this steam will condense, so a downspout is provided to drain the water off.

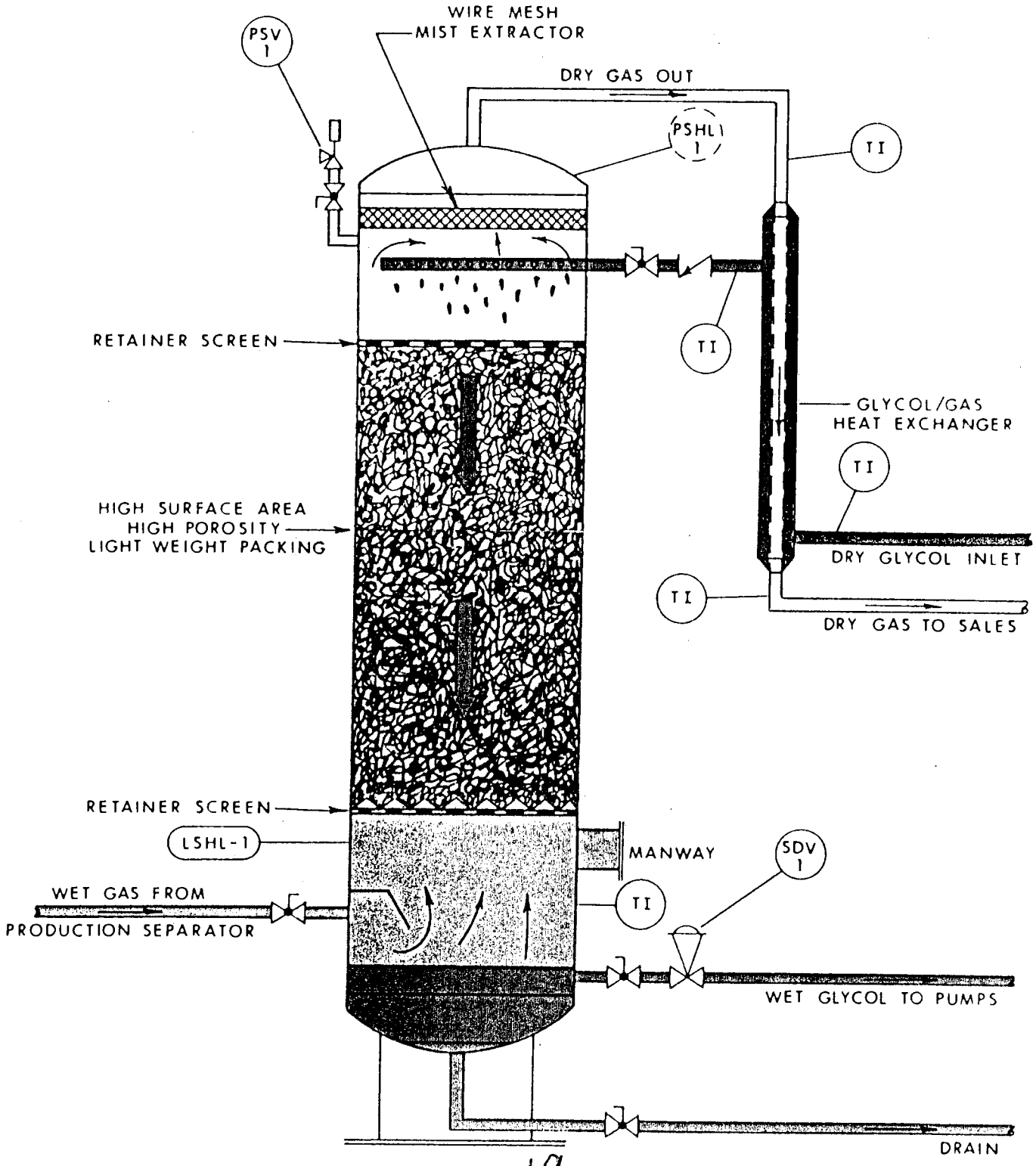
Now looking back at the reboiler, a weir or downcomer holds a level of glycol in the reboiler above the heating tube. As the glycol is purified, it spills over the weir into a separate compartment, then leaves as dry glycol, to start the cycle again.

A CLOSER LOOK AT COMPONENTS

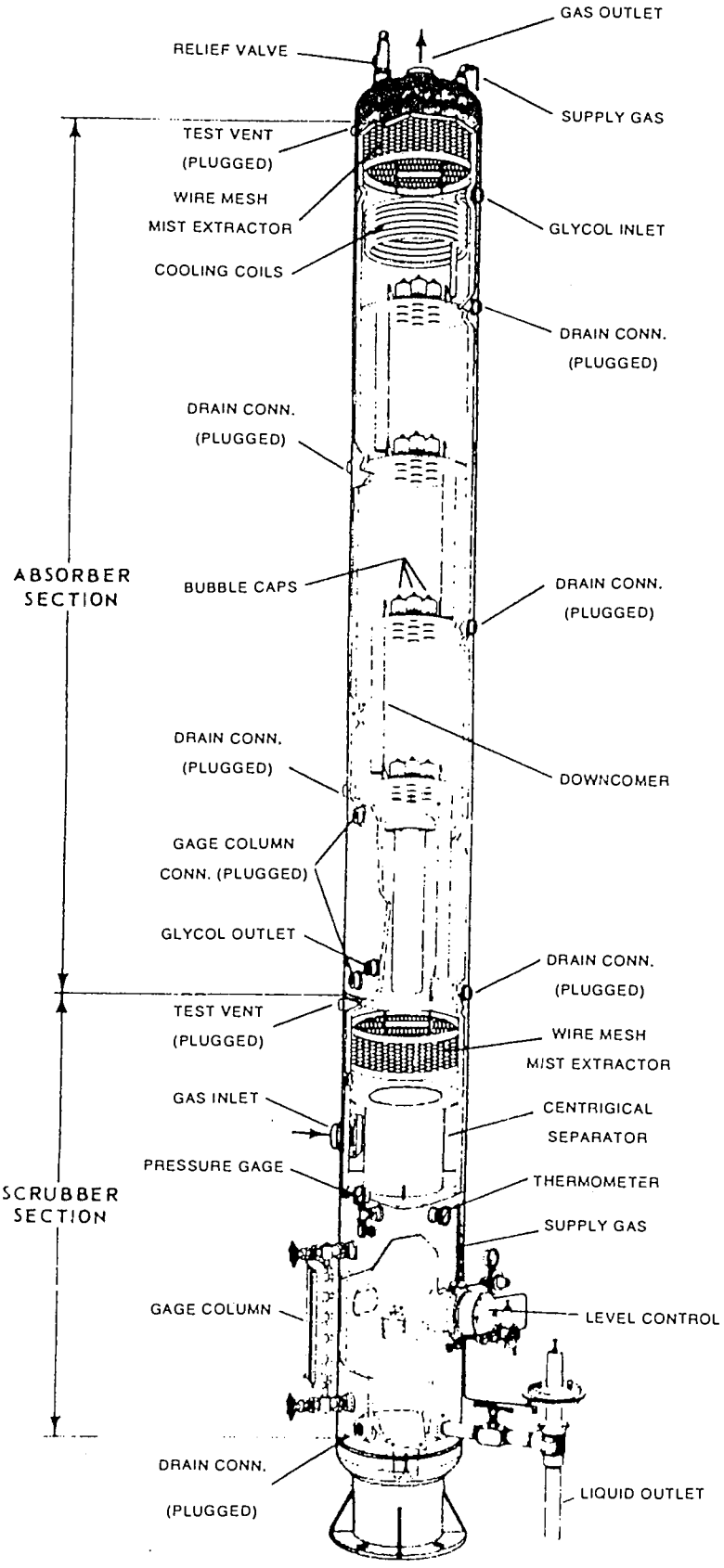
THE CONTACT TOWER

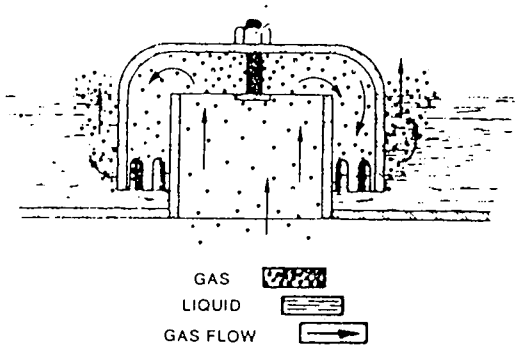
The contact tower, also known as the contactor or absorber, contacts the gas and glycol. The most common method is through the use of bubble caps, trays, downcomers, and weirs. As previously described, gas passes up through a riser from the bottom of the tray and is forced down by the cap. The gas passes through slots in the cap and is broken up into bubbles. These bubbles float up through a layer of glycol contained on the top of the tray. A slight froth is formed and it is in this froth where the intimate gas/glycol contact takes place. The glycol enters the contactor and spills onto the tray at one end. It travels across the tray to the opposite end where it spills down through a downcomer to the next lower tray. Weirs, or dams, at each end of the tray hold a constant level of glycol on each tray and also serves to establish a constant liquid seal at the bottom of the downcomer. This liquid seal prevents gas

GAS / GLYCOL ABSORBER
PACKED COLUMN
WITHOUT INTEGRAL SCRUBBER

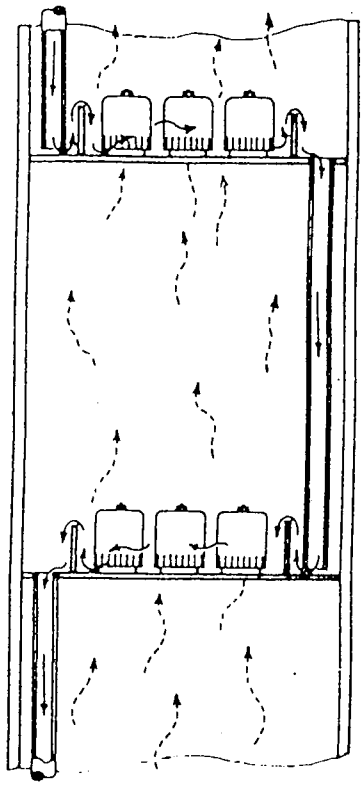


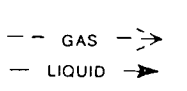
TYPICAL ABSORBER TOWER WITH SCRUBBER SECTION





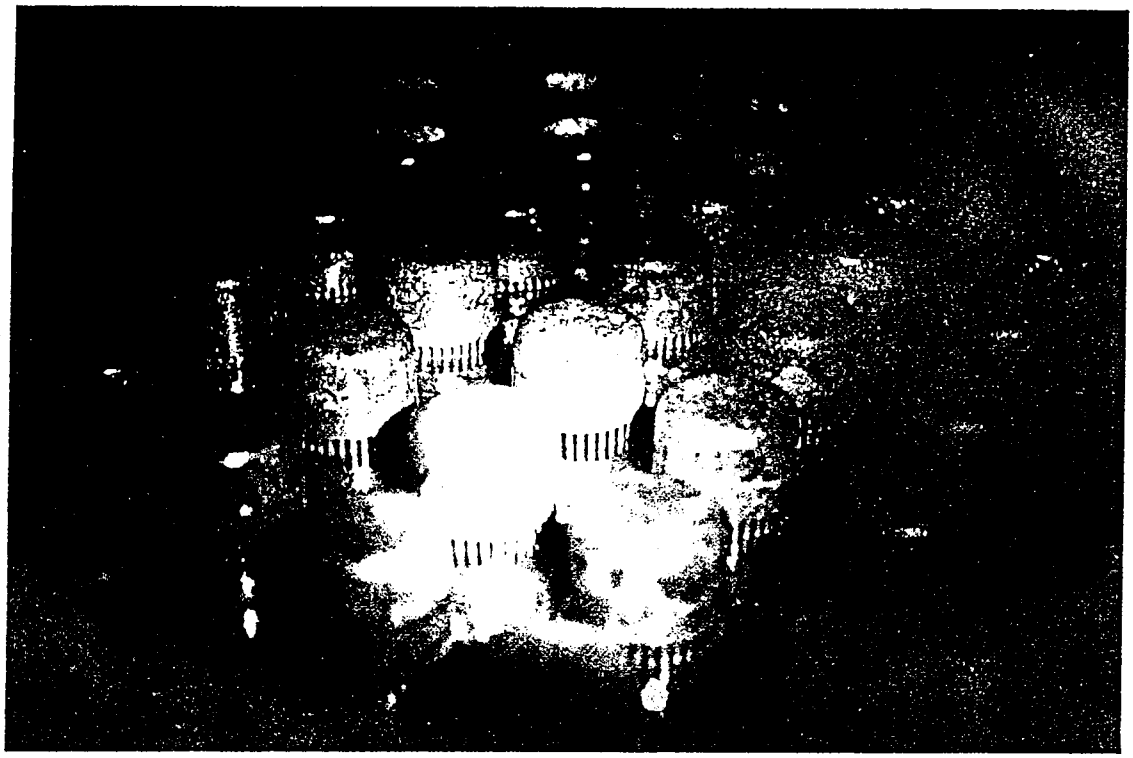
BUBBLE CAP DURING OPERATION



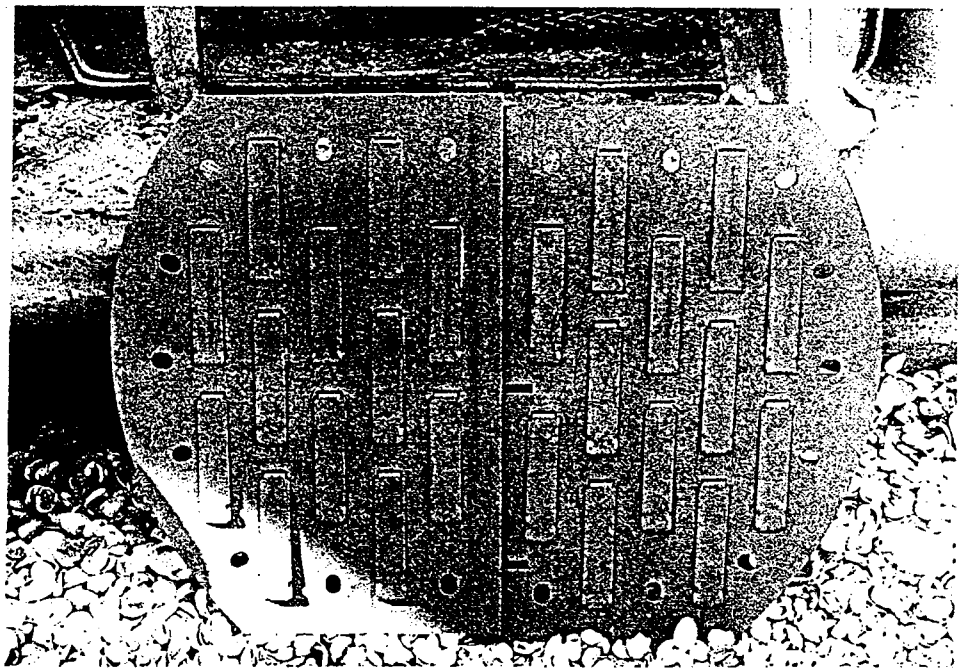


FLOW DIAGRAM

FIG. 10a



ARRANGEMENT OF BUBBLECAPS INSIDE THE CONTACT TOWER



VALVE TRAY SHOWING VALVES OR FLAPPERS POSITIONED OVER SLOTS IN THE TRAY BOTTOM

from short circuiting up the downcomer. The glycol travels down each successive tray accumulating in the bottom.

Some contactors use alternate methods for contacting the gas and glycol. The next most common contactor is the "packed tower". The vessel is packed with ceramic saddles or pall rings. This packing forms many "channels". The glycol, as it enters the tower, is distributed over the packing and runs down through the many channels to the vessel bottom. The gas enters the tower near the bottom and travels upward through these same channels, contacting the glycol on its way down.

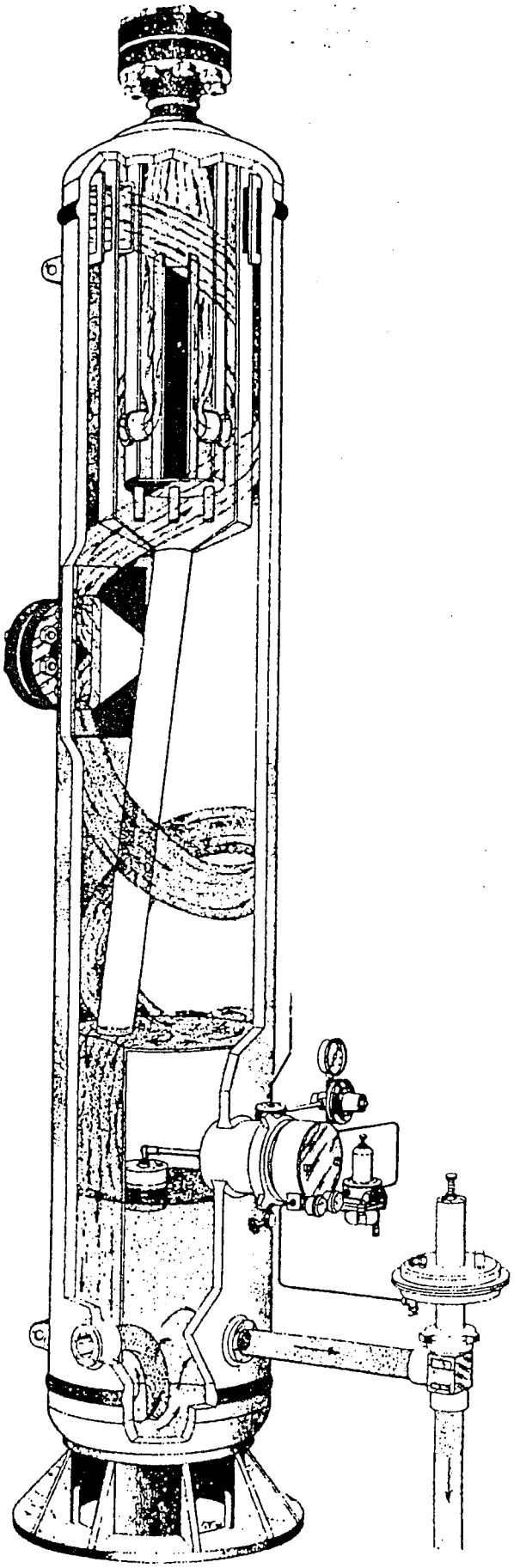
Other types of trayed towers employ valves or clappers. The gas moves upward through a hole in the bottom of the tray. Over the hole is a device that flutters or flaps in an up and down manner breaking the gas stream into bubbles which from the froth layer. The most common is the "Nutter valve".

In other towers the trays are "perforated" with many hundreds of tiny holes. The gas stream that passes through these holes is so small that it breaks up into the bubbles necessary to form the froth. The perforated tray is inexpensive to fabricate when compared to bubble cap or valve trays. However, the gas capacity range that can be effectively dehydrated is extremely limited.

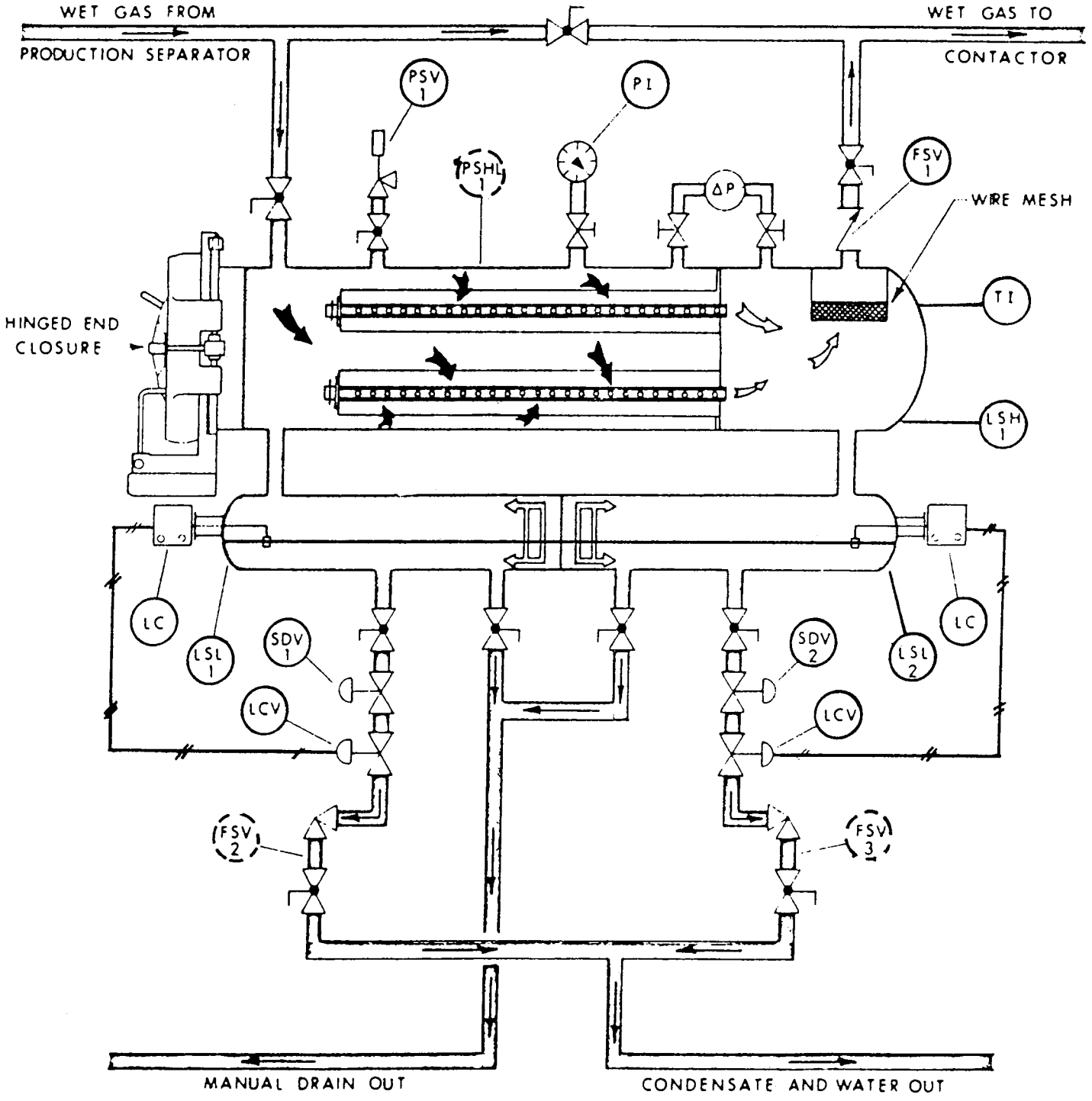
The latest method of contacting the gas and glycol in the tower is called a matrix. The matrix resembles corrugated metal affixed side by side with the corrugations set at opposite angles. Small holes are drilled in the corrugations. The gas passes upward through the holes and the channels formed by the opposing corrugation. The glycol runs down through these same holes and channels contacting the gas. The matrix sections will be layered in the contact tower with the corrugated channels of each layer at right angles to the layers above and below. In this manner the glycol and gas both are spread uniformly throughout the matrix in an organized manner.

In order for the contactor to be effective the gas entering the contactor must be as clear of free liquids as possible. Many dehydration systems will have a two phase separator immediatly upstream of the contactor to scrub the gas free of any liquid mist that may be entrained in the stream (Fig. 11). Some contactors have an internal "scrubber" which comprises approximately the lower one third of the vessel. In this type of contactor the glycol is collected on a "chimney" - a large stack with a covering or shield over the top. This allows the gas to pass upward from the scrubber section to absorber section while preventing the glycol from being lost out of the scrubber section with the fluids collected there. (Fig. 10).

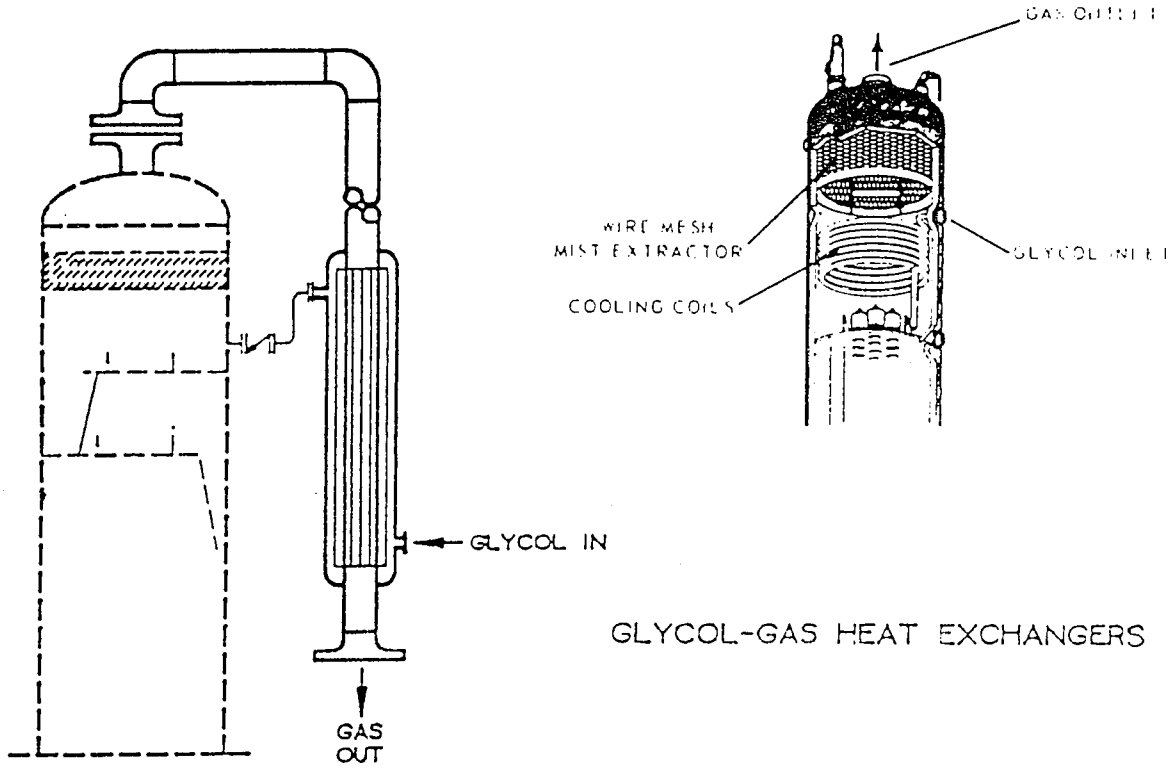
Some contact towers have an internal three phase separator with bucket and adjustable weir. These towers are distinguishable in that the lower section will have two sets of level controls and two liquid dump valves for fluid evacuation.



INLET SCRUBBER



Most contactors have a gas/glycol heat exchanger. It is important that the temperature of the glycol entering the contactor be near the temperature of the gas to prevent foaming. Two basic types of exchangers are used. The shell and tube type has the outlet gas pipe as the center "tube", while the dry glycol travels up the "shell" side around it before entering the contactor (Fig. 12). The coil type is a coil or set of coils inside the contactor through which the inlet dry glycol must pass before spilling on the top tray. The heat exchange takes place as the gas passes upward around the coils before exiting the tower through the mist extractor (Fig. 12).



GLYCOL-GAS HEAT EXCHANGERS

Besides preventing foaming of the glycol brought about by too extreme a temperature differential, the gas/glycol heat exchanger also serves another purpose. Hot glycol entering the contact tower may elevate the temperature of the gas surrounding it. As previously mentioned warmer gas has a greater capacity to hold water. If the hot glycol entering the tower warms the surrounding gas too much, the gas will not give up its remaining water to the glycol. The maximum temperature at which the gas will continue to give up its water vapor to the glycol is referred to as "the equalibrium temperature". When glycol heats the surrounding gas to a point where the gas will no longer give up its water vapor, the equalibrium temperature is said to be broken.

THE REBOILER

The function of the reboiler is the purification of glycol through distillation. Triethylene glycol begins to thermally decompose somewhere near 404 degrees Fahrenheit. Water boils at 212 degrees Fahrenheit. By heating the glycol above the boiling point of water but below the decomposition point of glycol (404 degrees Fahrenheit) water is driven off in the form of steam.

The reboiler has two major internal components, the heat source and the weir, and one external component, the still column (Fig. 13).

The heat source may be derived from several possible choices. The most common is direct fire. A gas or oil fired burner directs a flame down a "firetube" inside the reboiler. Exhaust gases are channeled out through a tack. Many units utilize exhaust gases from compressors or generators as a heat source. As with direct fired units, these exhaust are channeled through a tube contained in the reboiler. Occasionally these exhaust gases are used to heat a transfer media or "hot oil". The hot oil is then pumped through a tube bundle or heat exchange bundle which replaces the fire tube. Electric heaters are now being utilized both as a primary heat source or a supplement heat source for the glycol in the reboiler or the heat transfer media. On some older units the heat source may be external. A side stream of glycol may be pumped through a set of coils contained in a heat box through which compressor exhaust is channeled. This glycol is then returned to the reboiler and is used to heat the glycol contained in the reboiler. The same principle may be used to heat a transfer media as previously described.

The second major internal component of the reboiler is the weir. The weir, or dam, is designed to hold a level of glycol over the heat tubes to prevent overheating of the tubes and premature tube failure.

To further purify glycol, some reboilers have an added feature - "stripping gas" (Fig. 14). Hot gas has an affinity for water. So gas is bubbled through the hot glycol in the reboiler to remove water that was not cooked out. This gas may be put directly into the reboiler, or it may be added to the storage tank, so that is can be percolated through a packed column between the two vessels. This column is called a "Stahl" column after its inventor. The Stahl column also serves as the weir (Fig. 15). The dry glycol spills downward by gravity over the packing, while the gas goes upward, removing even more water. By this method, the glycol may be purified almost 100%. This method has another advantage. It prevents air form coming into contact with the dry glycol in the storage tank, preventing oxidation of the glycol. Oxygen in the air will decompose glycol to some extent and cause corrosion in the system. Stripping gas can reduce the temperature at which the reboiler must operate and/or reduce the glycol circulation rate necesary to dehydrate the gas adequately.

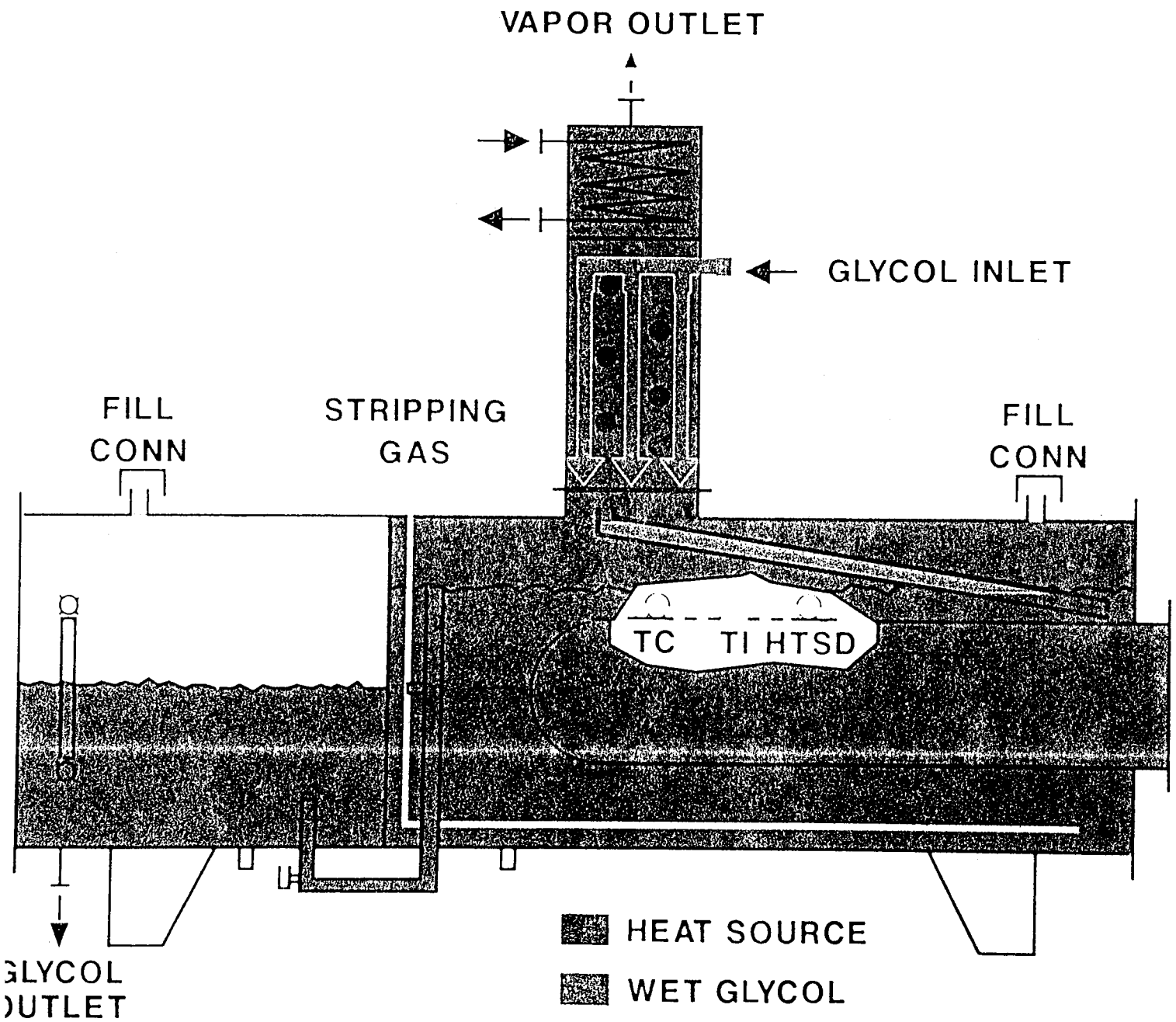
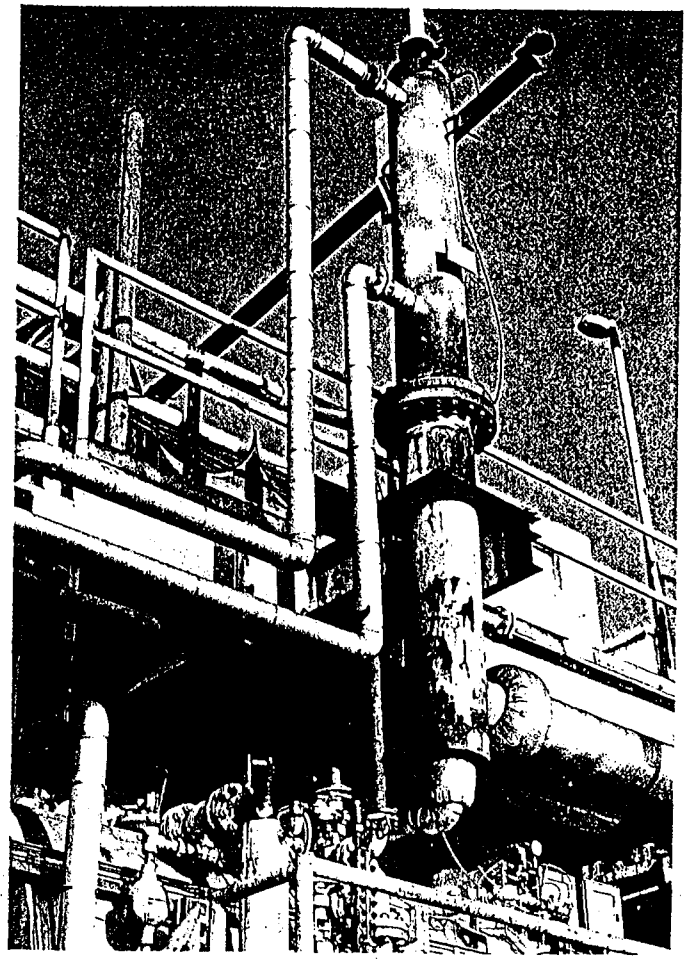
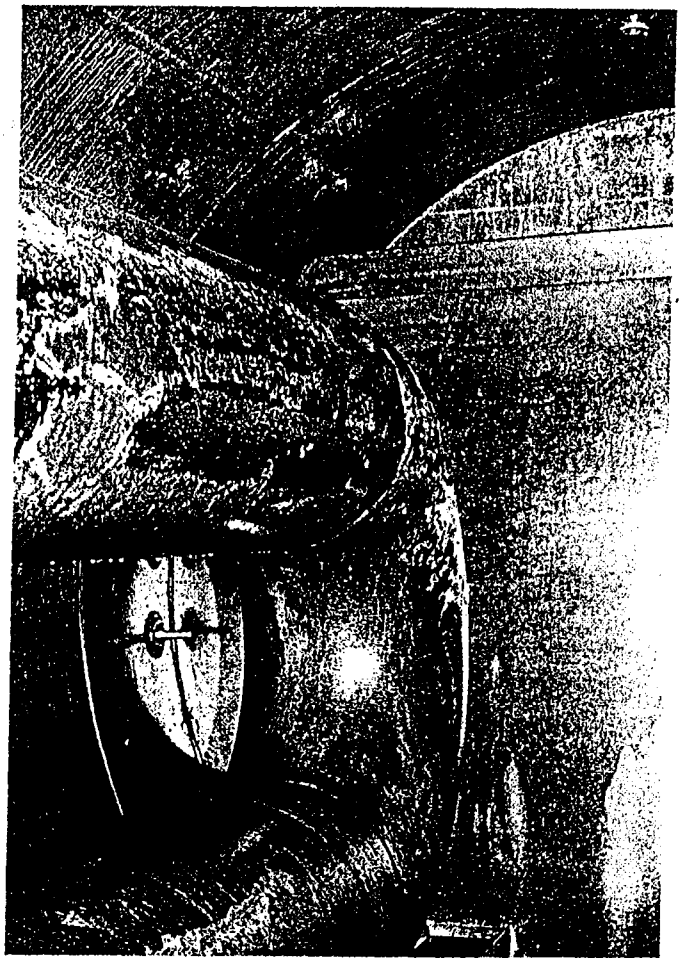

VAPOR OUTLET
GLYCOL INLET
FILL CONN
STRIPPING GAS
FILL CONN
TC TI HTSD
GLYCOL OUTLET
HEAT SOURCE
WET GLYCOL
DRY GLYCOL
WET GAS
DRY GAS
PACKING

FIG 13

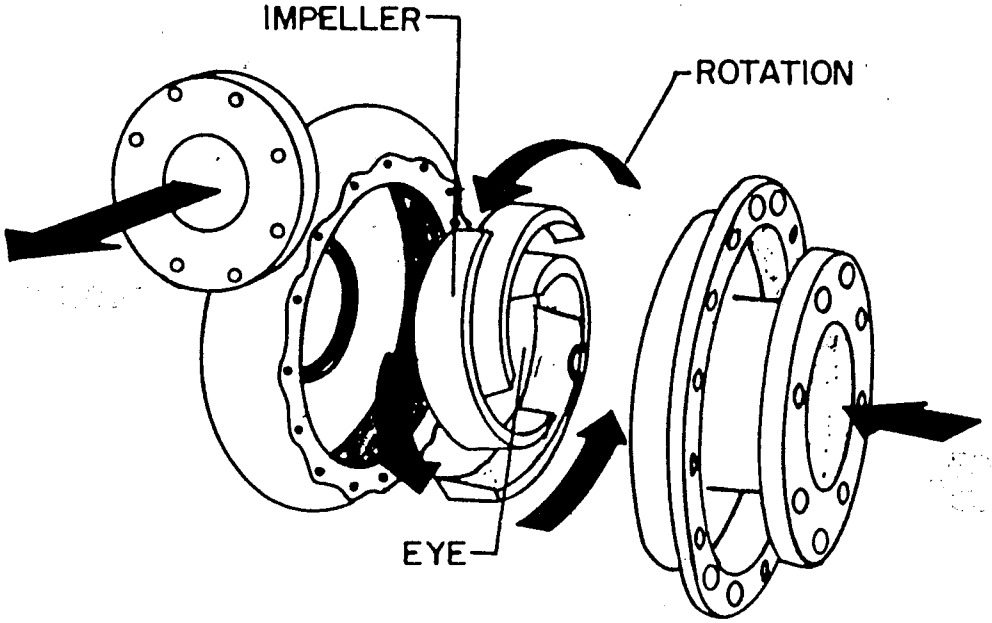
FIG. 13a

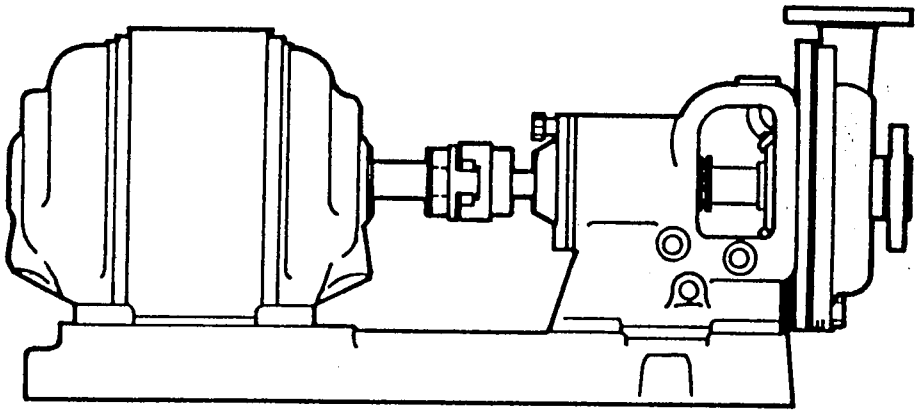


NOT ALL REFLUX COLUMNS ARE MOUNTED ON THE REBOILER, SOME ARE SEPARATE VESSELS.

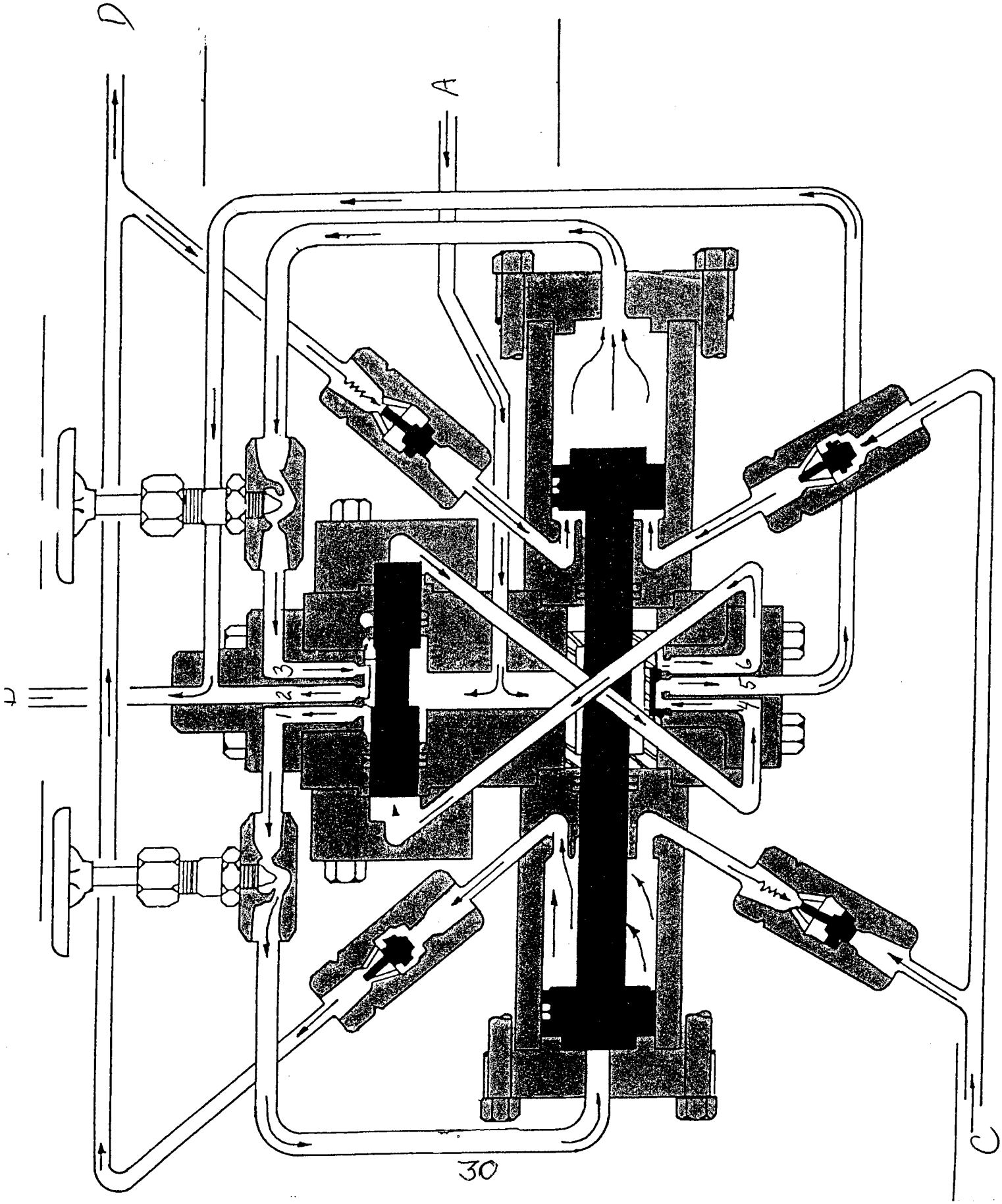


THE DIRECT FIRED HEAT TUBE IN PLACE INSIDE THE REBOILER. NOTE THE WEIR HEIGHT HOLDING GLYCOL OVER THE FIRE TUBE AND THE BAFFLE BEHIND THE WEIR PREVENTING VAPOR COMMUNICATION FROM THE SURGE TANK.

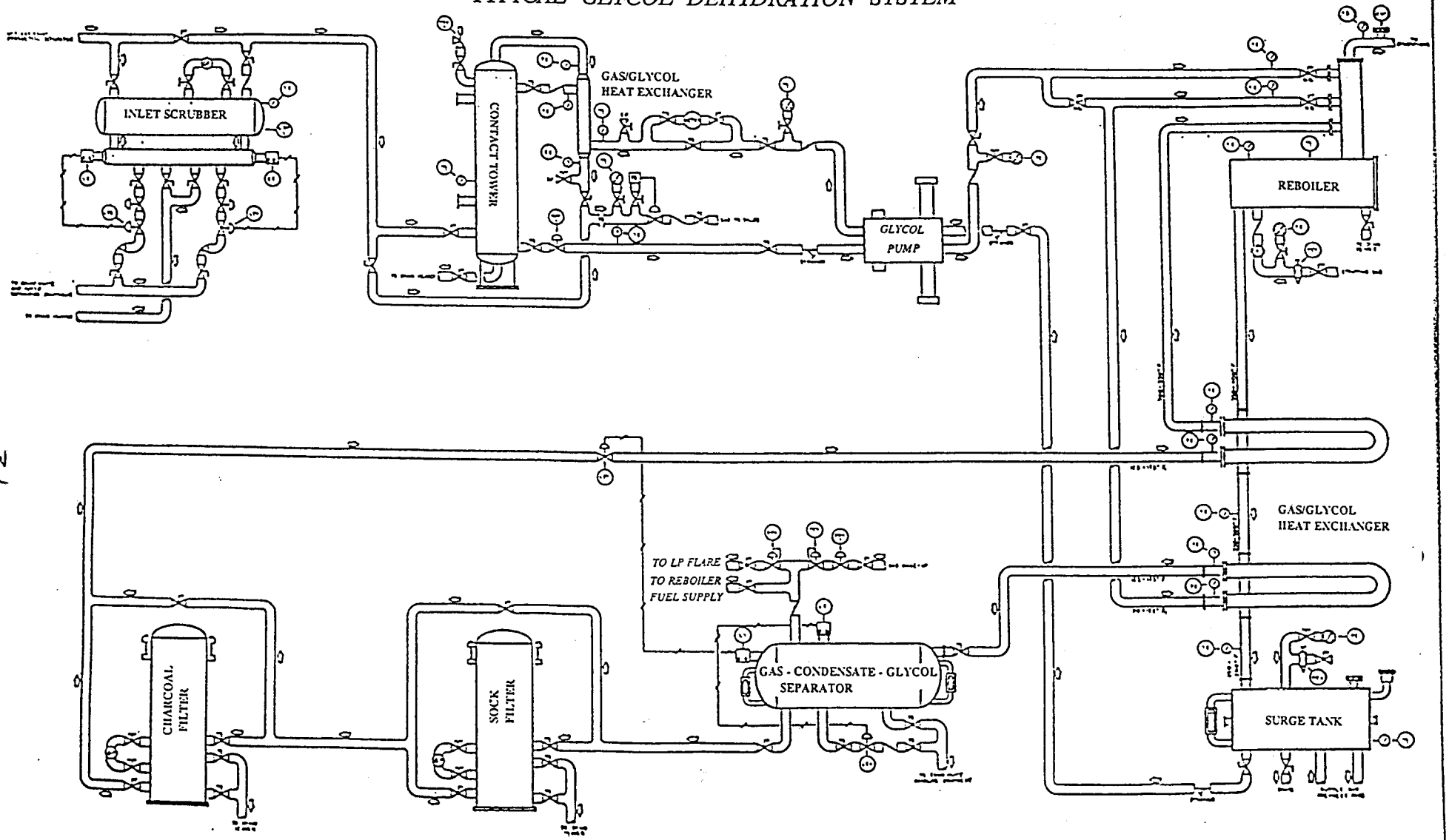

IMPELLER
ROTATION
EYE



GLYCOL POWERED PUMP
(KIMRAY)



TYPICAL GLYCOL DEHYDRATION SYSTEM



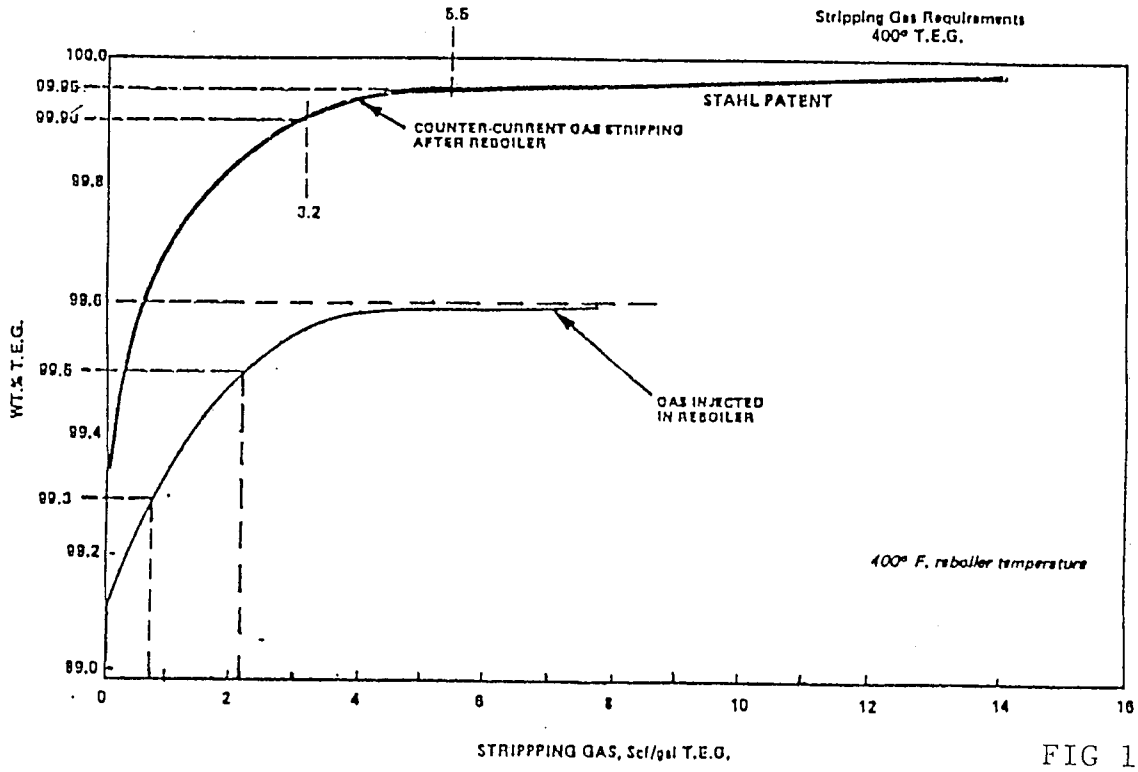


FIG 14

THE STILL COLUMN AND REFLUX CONDENSER

The still column is a large cylinder that sits vertically atop the reboiler (Fig. 16). This cylinder contains packing (either ceramic saddles or stainless steel pall rings) used as surface area to distribute heat to the glycol. Water vapor as steam travels upward through the packing and exits to atmosphere through the top of the still column. Wet glycol enters near the top of the still and spills down through the packing to the reboiler. The vapors traveling upward from the reboiler heats the packing. As the glycol travels down through the heated packing water begins to be driven off as steam. Units utilizing efficient heat exchangers may drive off as much as 75% to 80% of the water from the glycol in the still column before it actually enters the reboiler.

As water vapor travels up through the still column and exits from the top, it carries with it trapped glycol vapor. To prevent the loss of glycol vapor, the still column utilizes a "reflux" section located atop the packed portion of the column. In the reflux section, a surface area is cooled to a point where some of the steam and glycol vapor will condense into a liquid. Glycol vapors, escaping the still column with the steam, are attracted to the film of condensed liquid (primarily water) covering the cool surface area where they too are condensed. The liquid

GLYCOL REBOILER (STAHL COLUMN)

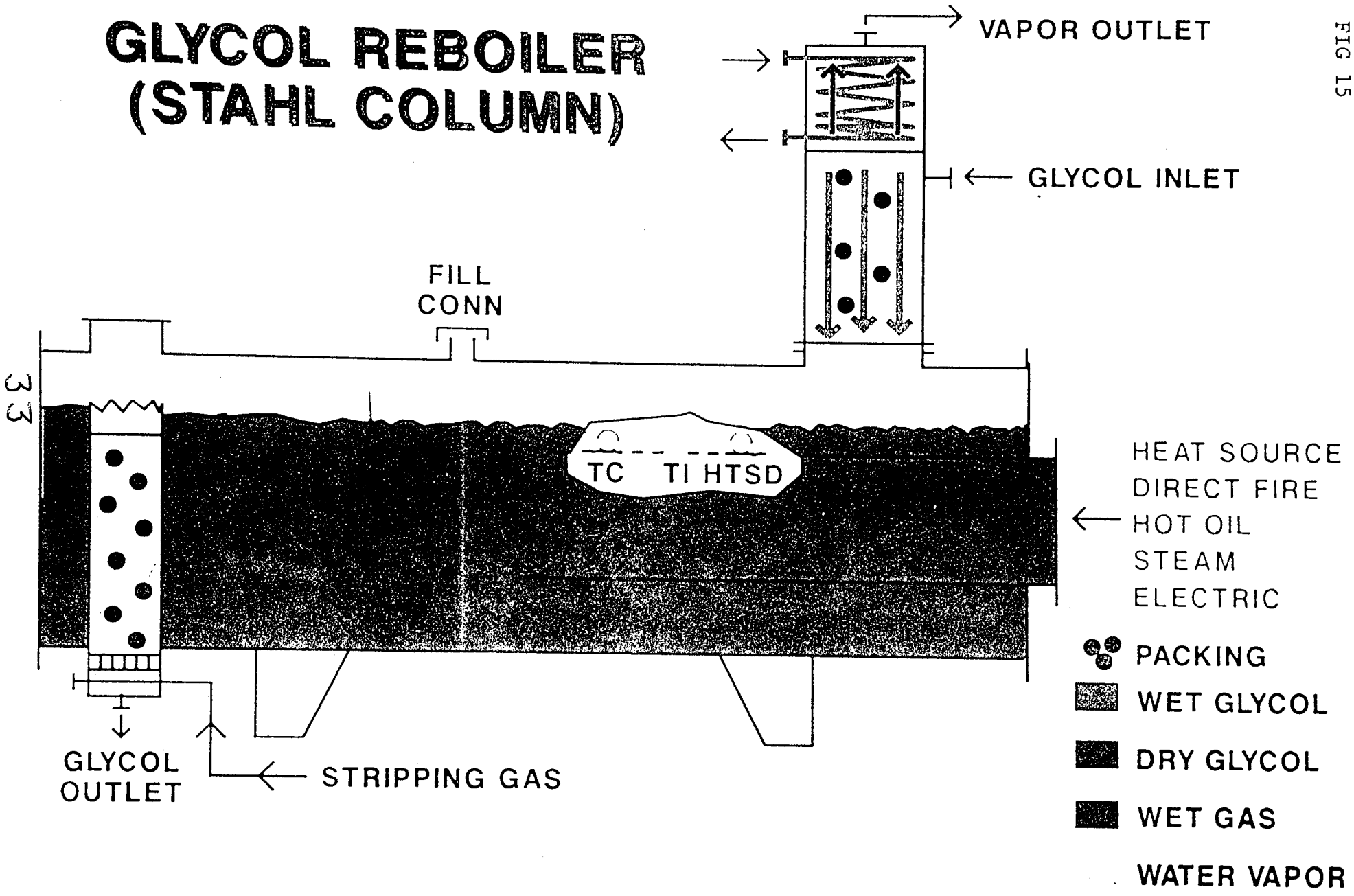
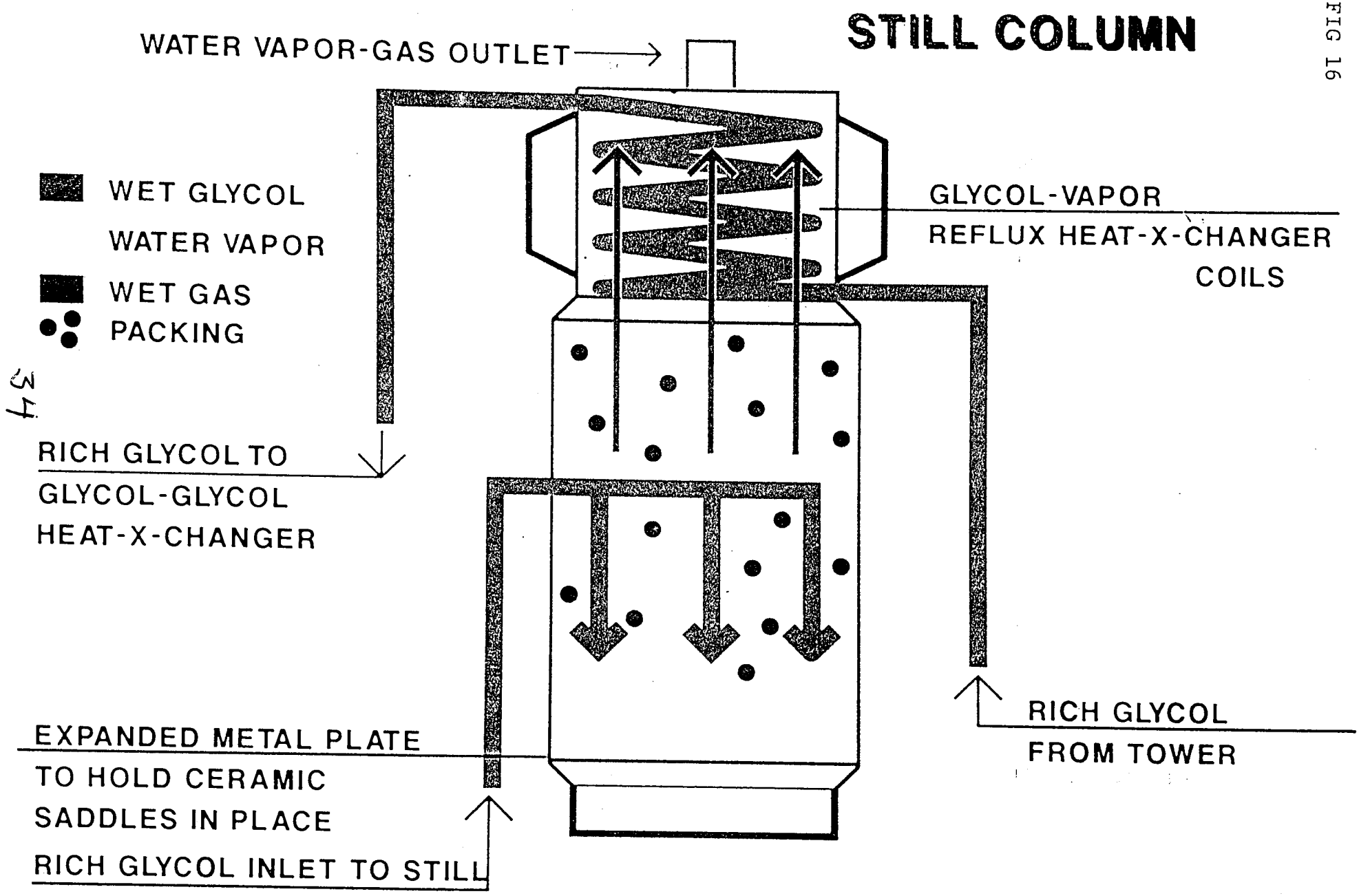


FIG 15

STILL COLUMN

FIG 16



droplets then gravitate back down the still column into the reboiler for re-distillation. In this manner, excessive glycol loss due to vaporization is prevented.

The most common method of reflux found on larger reboilers is through the use of "reflux coils". These are coils found in the top of the still column through which flows a stream of cool, wet glycol from the contactor. A by-pass valve may be used to regulate the flow through the reflux coil. In this manner, excessive condensation of steam may be prevented. Over refluxing may lead to glycol saturation and reboiler over-load. Usually, a thermometer is placed in the top of the still column to monitor the reflux temperature. A vapor outlet temperature of 215 degrees Fahrenheit to 225 degrees Fahrenheit is considered ideal.

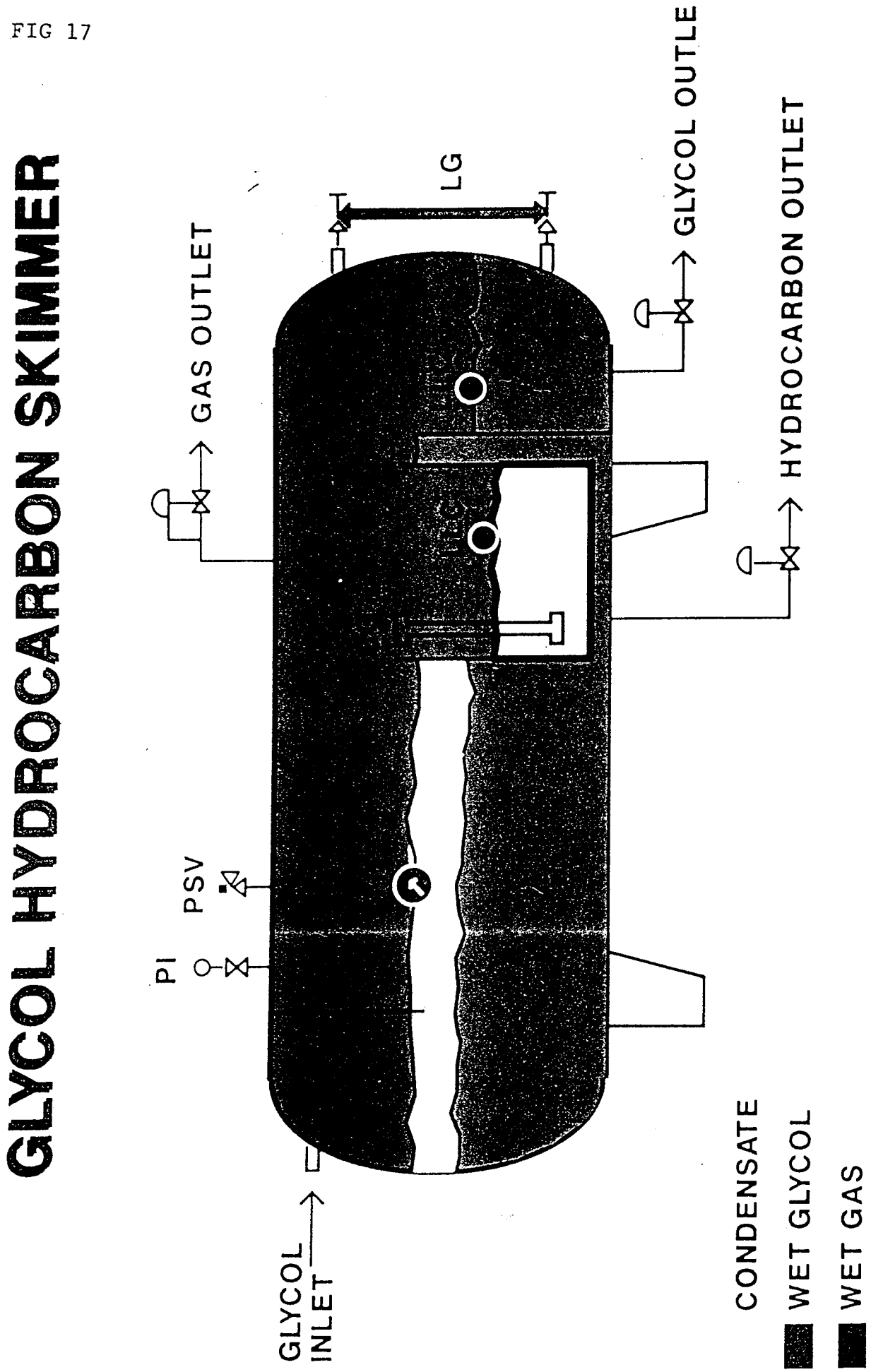
Smaller reboilers may achieve reflux in a slightly different manner. Instead of utilizing a coil, fins or plates called "heat sinks", are attached to the outside of the reflux section. These plates provide surface area used to radiate heat away from the still column. In this manner, the inside wall of the reflux section becomes cooler than the remainder of the still. Reflux condensation occurs on the inside wall of the still column reflux section. Reflux in this manner is less efficient since much depends on weather and external ambient temperature.

Some equipment manufacturers espouse a different philosphy with relation to reboiler distillation. On some units the glycol enters the reboiler below the packed section of the column. Distillation takes place solely in the reboiler. This type of column is referred to as a "reflux condenser". The reflux section of the reflux condenser operates the same as that of a still column. The packed section, however is no longer used to distribute heat for distillation. In the reflux condenser, condensed liquid from the reflux coil drops back into the packed section providing a liquid film over the packing. Glycol vapors escaping with steam from the reboiler must pass through the packed section. The watery film covering the packing recaptures the glycol vapor condensing it into droplets which wash back into the reboiler. In this manner substantially more glycol vapor can be recovered than in the prevoiusly described still column. It must be noted, however, that since distillation occurs solely in the reboiler, the operating temperature of the reflux condenser is lower than that of the still column. This translates into greater reflux condensation and demands greater reboiler heat duty.

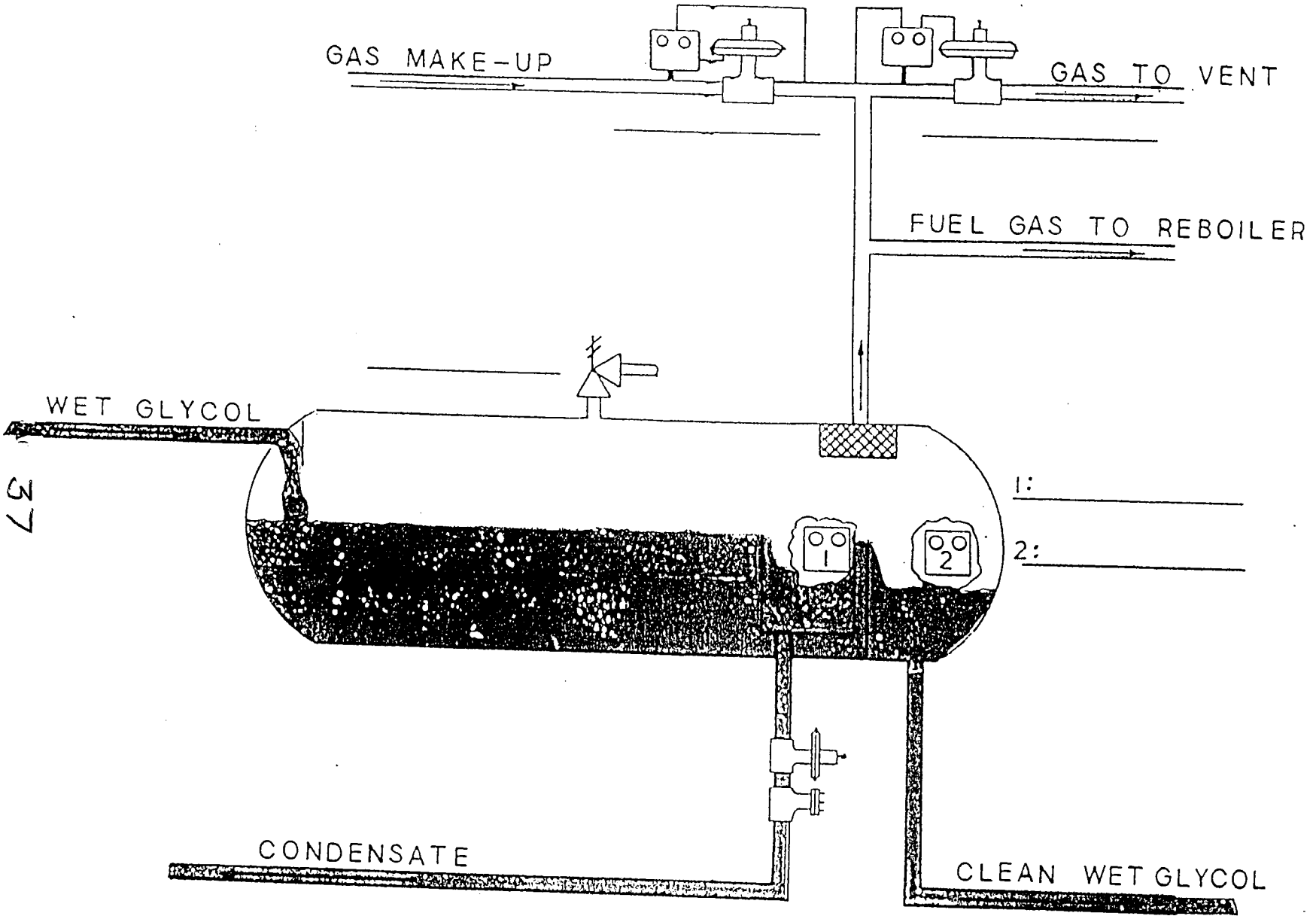
THE GAS-CONDENSATE-GLYCOL SEPARATOR

The gas-condensate-glycol separator, also known as the glycol-hydrocarbon skimmer, or just "skimmer", is usually nothing more than a horizontal three phase separator. The skimmer separates hydrocarbons from the wet glycol. Gas leaves through the top outlet, condensate is skimmed into the internal section, while wet glycol pases beneath this section then spills over the weir and leaves through the bottom outlet (Fig. 17). A few of the gas-condensate-glycol separators will be vertical vessels, but they perform in the same

FIG 17


GLYCOL HYDROCARBON SKIMMER
GAS OUTLET
LG
GLYCOL OUTLE
HYDROCARBON OUTLET
PI
PSV
GLYCOL INLET
CONDENSATE
WET GLYCOL
WET GAS

GAS / GLYCOL SEPARATOR



manner as horizontal separators. Condensate is skimmed into the bucket or upper section while glycol accumulates in the lower section. Some units will have a skimmer tank mounted on the reboiler next to the still column rather than having a glycol-condensate-gas separator. It performs the same job as the gas-condensate-glycol separator, that is removing gas and hydrocarbon condensate from the wet glycol before it enters the reboiler. However, it connot handle as large of quantities as the gas-condensate-glycol separator.

For economic reasons it is important that the gas collected in the skimmer be piped to a low pressure system where it can be used as fuel, instrument gas or compressed and sold.

Some installations will have only a two phose separator or "flash tank" to collect the gas while allowing filters elsewhere in the system to remove the hydrocarbons.

HEAT EXCHANGERS

A heat exchanger does just what the name implies - hot fluid flowing through one side

GLYCOL TO GLYCOL HEAT EXCHANGERS
FINNED (EXTENDED) SURFACE

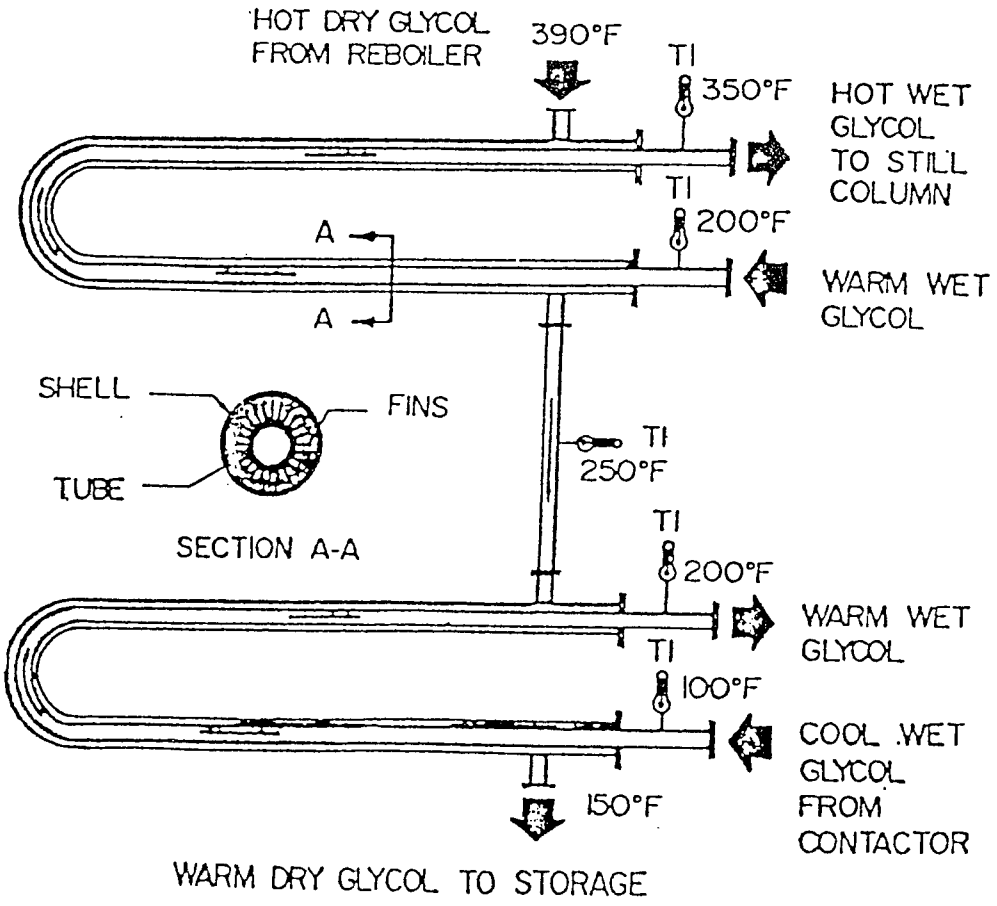


FIG 18

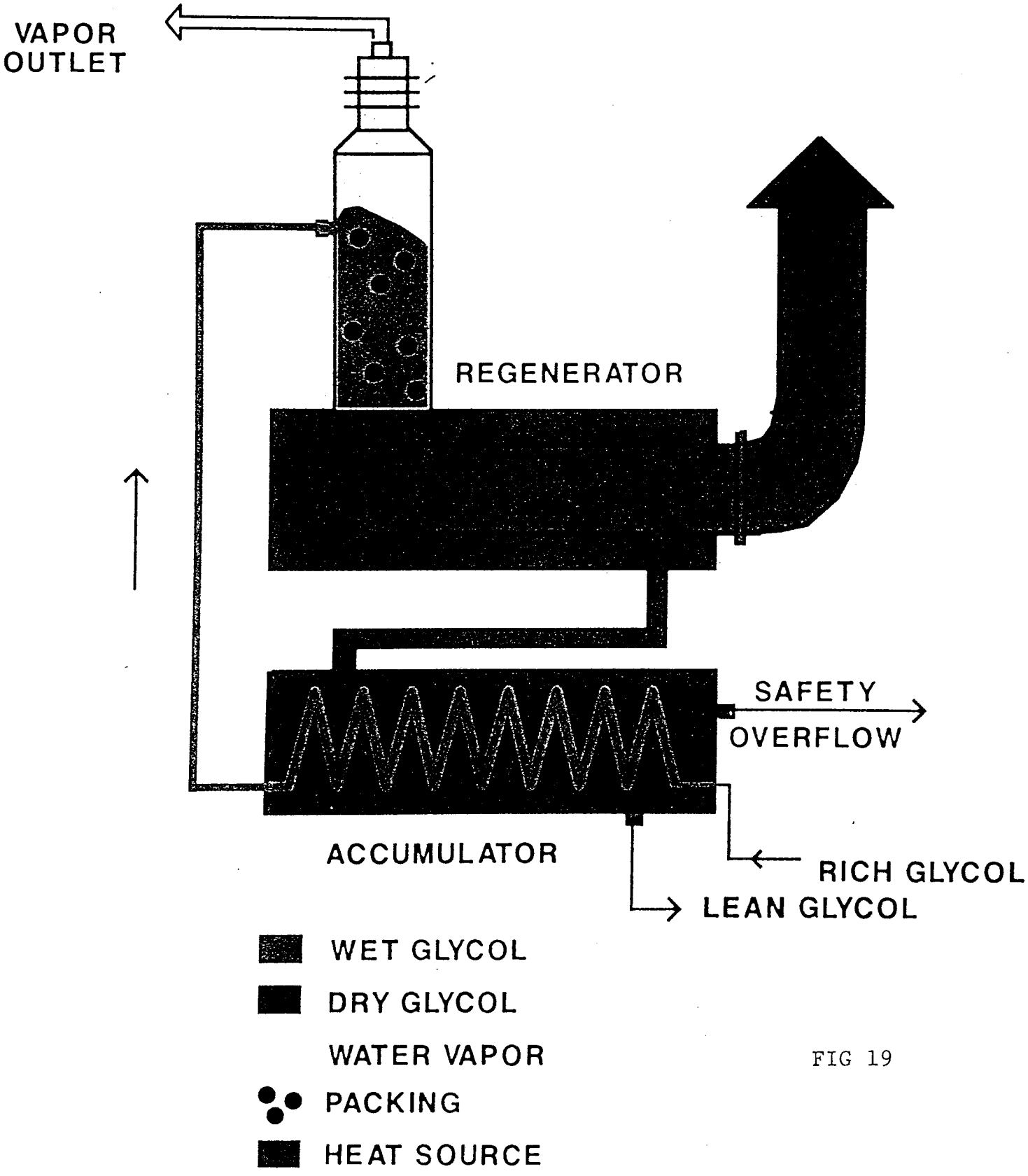

VAPOR
OUTLET
REGENERATOR
SAFETY
OVERFLOW
ACCUMULATOR
RICH GLYCOL
LEAN GLYCOL
WET GLYCOL
DRY GLYCOL
WATER VAPOR
PACKING
HEAT SOURCE

FIG 19

gives up heat to a cooler fluid flowing through the other side. These heat exchangers may be made in several shapes, with one fluid flowing through a tube, while the other fluid flows through a shell built around the tube. Dry hot glycol enters the shell and flows areound the tube to its outlet while the cooler wet glycol circulates through the tubes inside the shell. For example, the dry glycol enters the shell side at 390 degrees Fahrenheit and is cooled to 150 degrees Fahrenheit, while the wet glycol enters the tubes at 100 degrees Fahrenheit and is heated to 350 degrees Fahrenheit before leaving the heat exchanger.

There are other types of heat exchangers besides the shell and tube type. On some installations the wet glycol passes through a coil in the dry glycol storage tank for heat exchange.

Others may use a plate type exchanger. These resemble two plates of corrugated metal placed together and separated by a flat plate sandwiched between. Hot glycol flows through one corrugated plate while cool glycol flows counter-currently through the other. Heat is exchanged across the center plate.

As mentioned before, effective use of heat exchangers can drastically reduce heat requirements of the reboiler. In this way, smaller reboilers may be used in place of the bulky, more costly larger vessels. In addition, on direct fired reboilers the fuel usage is also reduced.

FILTERS AND STRAINERS

The most common problem encountered with dehydration systems is glycol contamination. It is therefore, extremely important that adequate filtration be provided on all units and that they be properly maintanined and serviced. Glycol impurities can be removed through the use of strainers, sock type filters and carbon filters.

Strainers are primarily used to protect the glycol pump from large abrasive particles which when allowed to enter the pump may damage pump internals. They are located on the high and low pressure suction lines on glycol powered pumps but only on the low pressure suction line of an electric powered pump.

Sock type filters are used to remove gritty solids and heavy tarry hydrocarbons. They are usually located downstream of the gas-condensate-glycol separator. In some cases they may be placed on the high pressure wet glycol line from the contactor or on the dry glycol line up or downstream of the glycol pump. Locating the sock filter on the dry glycol suction line to the glycol pump may cavitate the pump (should the glycol filter element plug) and starve the pump suction. Sock filter elements in filters located on high pressure lines should they plug, may disintegrate due to high defferential pressure across them.

Carbon or charcoal filters are used to remove liquid entrained hydrocarbons, well treating chemicals, compressor oils, or other impurities that may cause foaming. Activated carbon adsorbs impurities from the glycol much as a sponge picks up water. Also, like a wet sponge,

once the carbon has saturated with impurities, any additional will flow right through (see Appendix "H").

THE STORAGE OR SURGE TANK (ACCUMULATOR)

The surge tank serves as a safe vessel for the addition of replacement glycol. It is usually kept half to two-thirds full, allowing ample room for thermal expansion of cool replacement glycol. The surge should be vented to atmosphere through an approximately ½ inch orifice in the fill connection cap. This allows the vessel to "breath" and prevents vapor build-up which could result in "vapor locking" the glycol pump. The surge tank may be an integral part of the reboiler or it may be a completely separate vessel. It sometimes contains a heat exchanger coil. Some manufacturers install a skim valve at about the level glycol should be kept. This allows "skimming" off of liquid hydrocarbons that may accumulate through condensation. A gauge glass on the surge tank allows for quick determination of glycol level and is also used to calculate glycol usage.

GLYCOL PUMP

There are two basic types of glycol pumps used on most glycol reconcentration units, the glycol-gas powered pump and the electric driven positive displacement piston pump.

The glycol-gas powered glycol pump is the mainstay of the industry. Unlike an electric-powered positive displacement pump, the glycol-gas powered pump requires no contactor glycol liquid level control and dump valve, or auxiliary power (electricity). The gas consumption is relatively low and when used in conjunction with a glycol hydrocarbon skimmer or flash tank very little gas loss is experienced.

Most electric driven piston pumps require a tiny glycol leak in the piston rod packing for lubrication. The glycol-gas powered pump is a completely sealed unit preventing loss of glycol. Glycol-gas powered pumps (the most common being the Kimray) have very few moving parts which translates into less wear and simpler field repairs. The Kimray glycol-gas powered pump has an acute sensitivity to hydrocarbon distillate. Contact with this distillate, which may be entrained in the glycol passing through the pump, swells o-ring seals in the pump causing premature pump failure. On installations where this entrained distillate is expected, electric pumps may be most desirable. Electric piston pumps are also more resilient to grit and debris that would damage the glycol-gas powered pumps. Electric powered pumps are much better suited to pumping glycol which may exceed 200 degrees Fahrenheit which is a limiting factor on glycol-gas powered pumps with standard Buna-N o-rings. Glycol over 200 degrees Fahrenheit damages the o-ring seals in glycol-gas driven pumps (see Appendix "D", "E", and "F").

ONCE MORE - THE FLOW

The wet gas passes through a separator to remove the free water, then enters the contactor. After passing through the contactor, the dry gas leaves and then passes through the gas to glycol heat exchanger to cool the dry glycol before it enters into the tower. The gas then goes to sales.

Hot dry glycol leaves the reboiler and passes through the dry glycol to wet glycol heat exchangers. The dry glycol is cooled by the wet glycol stream, then passes into the storage tank. From the storage tank, it goes through a strainer then to the pump, it passes through the gas to glycol heat exchanger for final cooling, then enters the contactor. Inside the contactor there are trays, weirs, bubble caps and downcomers to insure intimate gas to glycol contact. As the glycol moves down from tray to tray, it becomes wetter, until it accumulates in the bottom saturated with water. As the gas passes upward through the trays, it becomes drier, and leaves the contactor out the top.

On systems utilizing a glycol-gas powered pump cool wet glycol leaves the bottom of the contactor, passes through a strainer and powers the pump. The wet glycol takes a pressure drop through the pump, then passes through the reflux coil in the reboiler still column (Fig. 20).

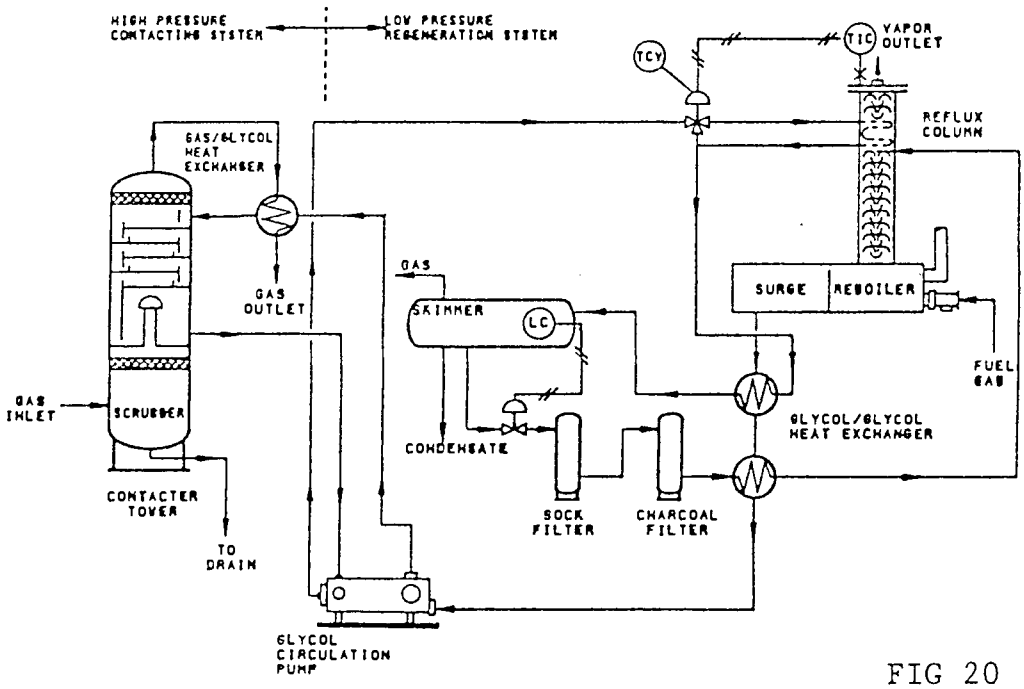


FIG 20

For units with an electric powered piston type pump, the cool wet glycol leaves the bottom of the contactor, passes through a posichoke and level control operated motor valve, where a pressure drop occurs. The glycol then passes through the still column reflux coils (Fig. 21).

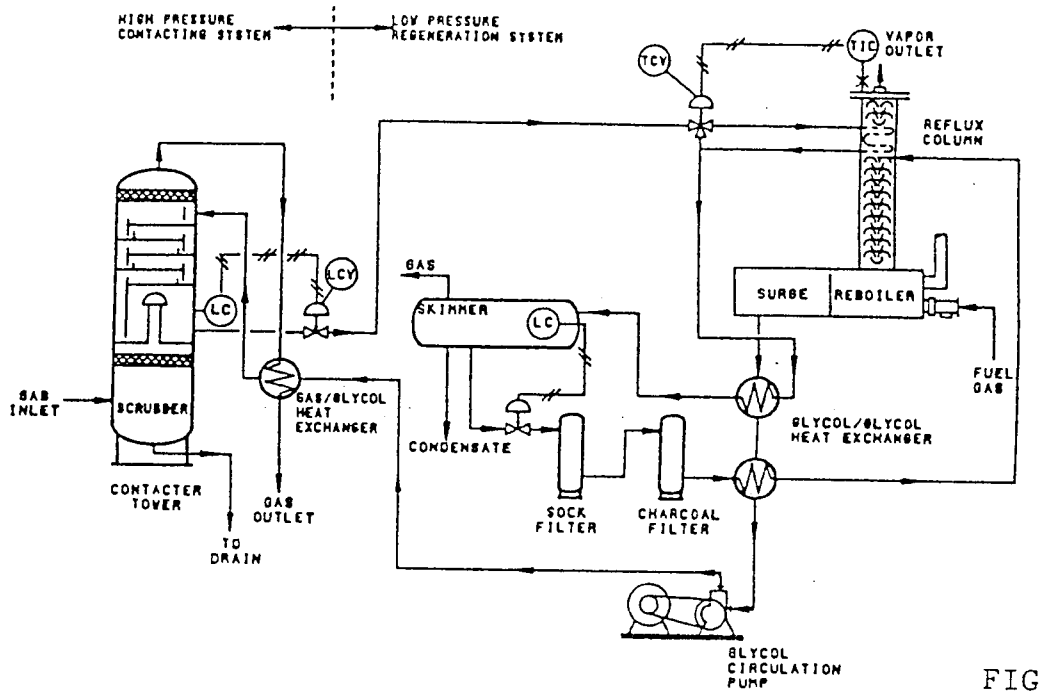
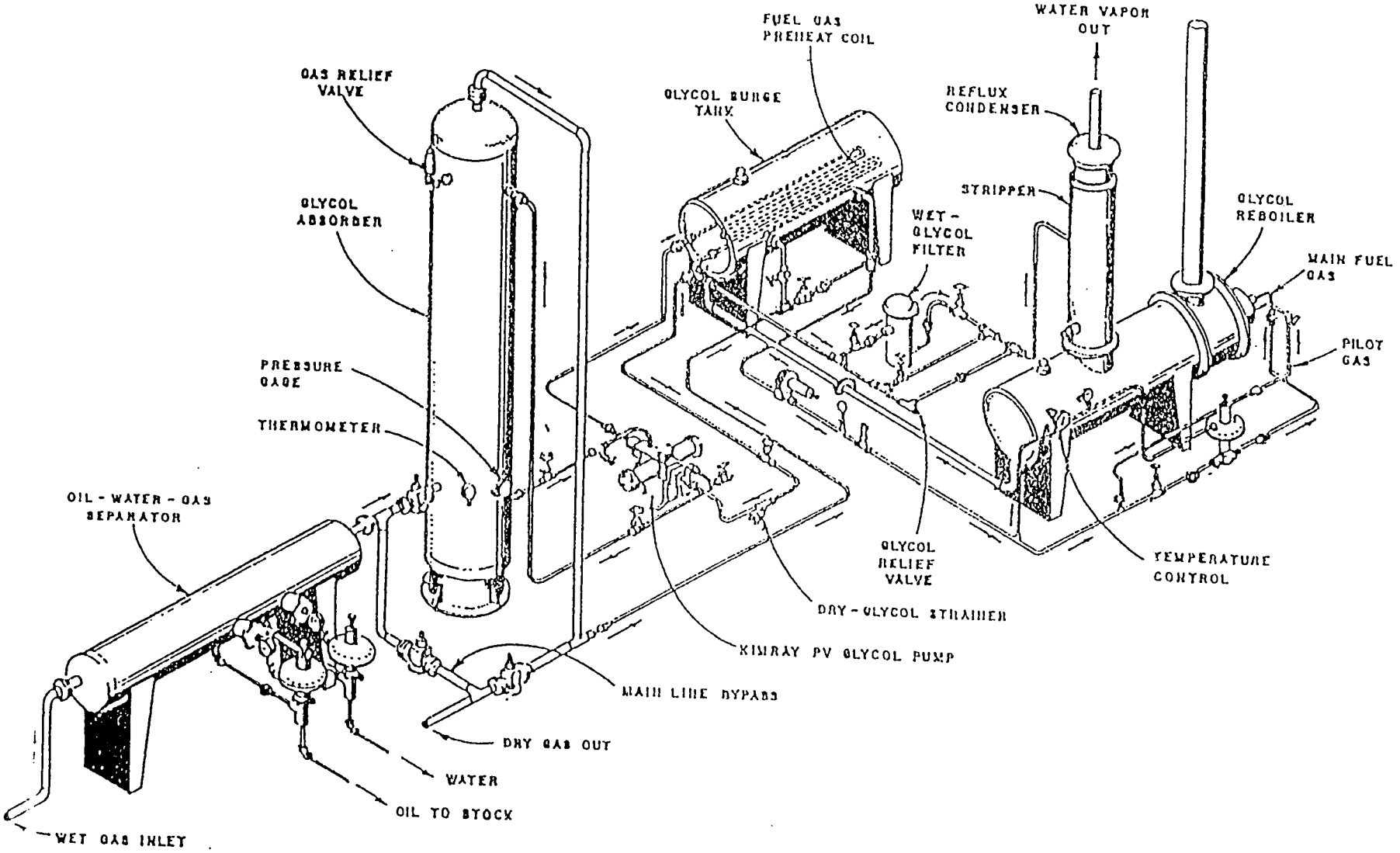


FIG 21

From the reflux coil it flows through the first dry glycol to wet glycol heat exchanger, then into the glycol-condensate-gas separator, where insoluble hydrocarbons are removed. From the separator, the glycol passes through the filter to remove tarry hydrocarbons, then through the second dry glycol to wet glycol heat exchanger and into the reboiler still column. In the top of the reboiler still column cool wet glycol flows through reflux coils, to prevent glycol leaving as a vapor. The wet glycol enters the column below the coils and spills downward through the packing and into the reboiler vessel. Heat is circulated through the tube to boil the water from the glycol. A weir holds the level of glycol above the heating tubes. Regenerated glycol flows over the weir and leaves through the outlet in the bottom.



FLOW DIAGRAM OF A LIQUID - DESICCANT UNIT *

Glycol Dehydration

Unit II

Operating Conditions
&
Limits

THE RULES MAY VARY

Glycol dehydrators depend on, and are limited by, the following variables: temperature, pressure, liquid levels, and flow rates throughout the system. No two systems' "personalities" are alike. Each units' personality is derived from the volume, temperature, pressure, and composition of the gas stream and the type and configuration of the equipment used to dehydrate that stream. Consequently there can be no firm set of rules and conditions given that would apply to the operation of all dehydrators all of the time. Knowing the limits of each variable, and understanding the factors that determine these limits, will allow the operator to adjust his units' operation and achieve the desired performance.

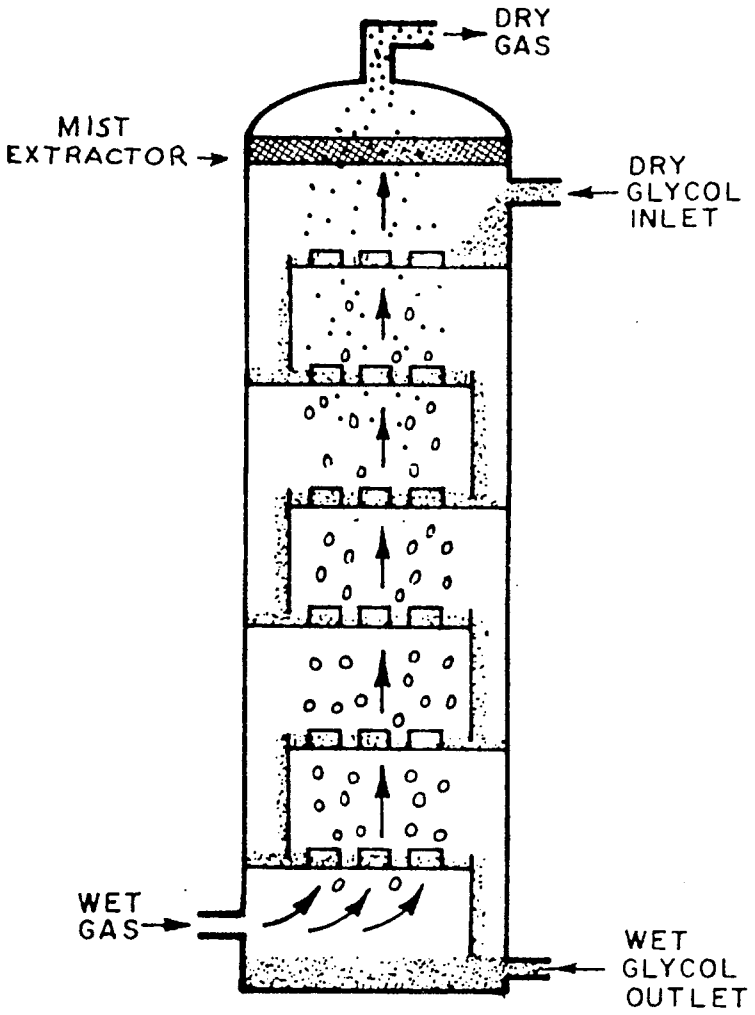
THE CONTACTOR - TEMPERATURE

The first of our variables to consider is the temperature of the gas entering the contactor. The best temperature range of the gas is from 80 degrees Fahrenheit to 110 degrees Fahrenheit, but you can still get pretty good dehydration from around 50 degrees Fahrenheit to 130 degrees Fahrenheit (Fig. 22). Hot gas has an affinity for water. Gas at temperatures around 130 degrees Fahrenheit and above will not release water to the glycol. Glycol below 50 degrees Fahrenheit has less hygroscopicity than warmer glycol and refuses to absorb water as easily. In addition, cold glycol is very viscous. Flow through the tower is hindered. The normal action of the bubble cap breaking the gas stream into thousands of tiny bubbles is altered. The bubble cap produces a larger bubble, inhibiting the frothing layer, and reducing the intimate gas/glycol contact.

Another temperature to be concerned with is the temperature of the dry glycol going into the top tray of the contactor. This is referred to as the inlet glycol approach temperature. The dry glycol temperature at this point should be less than 20 degrees Fahrenheit greater than the temperature of the gas. This is necessary because the equilibrium conditions between the glycol and the water vapor in the gas is affected by temperature. In other words, the glycol entering the top tray of the contactor may raise the temperature of the gas surrounding it and prevent the gas giving up its remaining water vapor. In addition, a drastic temperature differential also has a tendency to emulsify the glycol with any contamination it may contain. This causes escessive glycol foaming and subsequent glycol loss.

PRESSURE

The next variable to be considered is pressure. Good dehydration can be achieved at any pressure as long as the pressure is constant. Rapid pressure changes translate into rapid velocity changes. When rapid velocity change takes place in a contactor, the liquid seals between the downcomers and the trays may be broken. When this seal is lost, gas may



CONTACTOR

FIG 22

TEMPERATURE:

Gas Inlet - 80° to 110°F Best Range.
50° to 130°F Possible Range.

Glycol Inlet - 20°± that of Gas Inlet Temperature.

PRESSURE - Within Design Spec's.

LIQUID LEVEL - Mid-Way any sight glass.

FLOW RATE - Within maximum and minimum design spec's with relation to pressure.

channel up through the downcomer as well as the bubble caps and glycol will be swept out with the gas.

Note also that natural gas at low pressure contains a greater amount of water vapor. Operating pressure must be considered when sizing and troubleshooting dehy units. Be sure never to exceed the contactors design maximum working pressure (see Appendix "A").

LIQUID LEVELS

On units using glycol-gas powered glycol pumps the glycol liquid level will be controlled by the pump. However, if your unit has an electric driven pump to supply dry glycol to the contactor, then you will see a gauge glass near the bottom of the contactor and a liquid level controller operating a dump valve. Be sure the level is held steady in the gauge glass so that the flow rate is even. If the dump valve is allowed to snap-act instead of throttle, the reboiler gets slugged with glycol and can't do its job properly.

For contactors equipped with an internal scrubber section a separate level control and dump valve will be utilized to remove accumulated condensate liquid. Some contactors have a built-in separator in the bottom to remove hydrocarbon condensate from the wet glycol. If so, it will have two gauge glasses and two level controllers. The top one is for glycol, and the bottom is for condensate.

Be sure the liquid levels are kept about halfway in the sight glass. This insures an adequate volume of glycol to prevent gas blowby in the event of slow or sluggish controller operation.

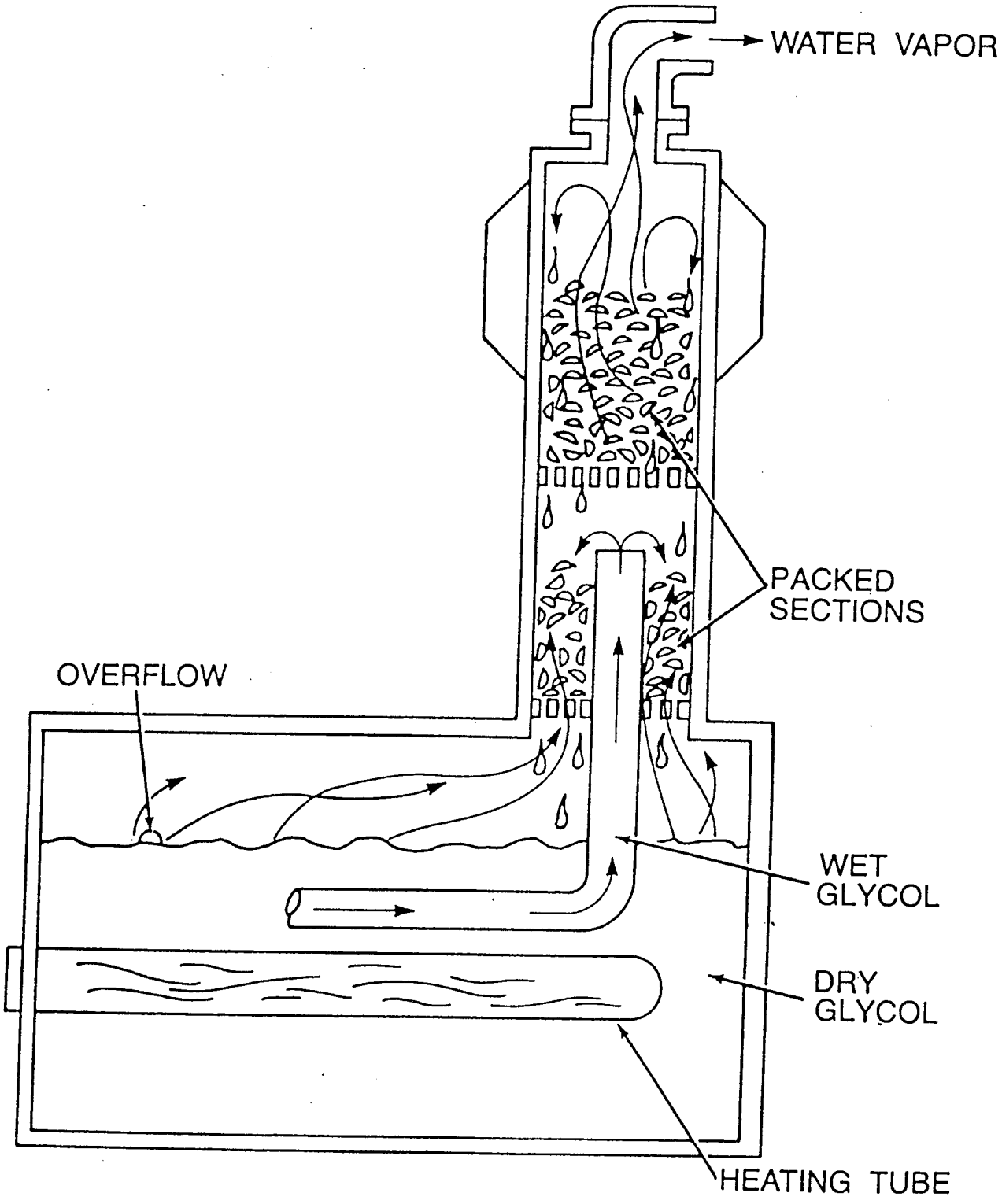
FLOWRATE

All contactors are rated for a maximum working pressure and a maximum volume of gas that can be dehydrated at that pressure. This maximum volume of gas is determined, by among other things, gas velocity through the tower. Too great a velocity through the tower will interrupt the glycol flow pattern across the trays and break liquid seals at the points where tray downcomers meet the trays. This in turn results in glycol being swept out of the tower with the gas. For a given volume of gas flowing through a contactor, to maintain an equivilent volume, if pressure decreases, velocity must increase. Therefore, the maximum gas flow rate for the contactor decreases proportionately with the lowering of operating pressure. In other words, the lower the operating pressure of a contactor, the less gas you can effectively dehydrate.

THE REBOILER

TEMPERATURE

One of the most important things you should watch in the operation of the whole system is the reboiler temperature. With everything else operating normally, you raise the reboiler



REBOILER AND STILL COLUMN

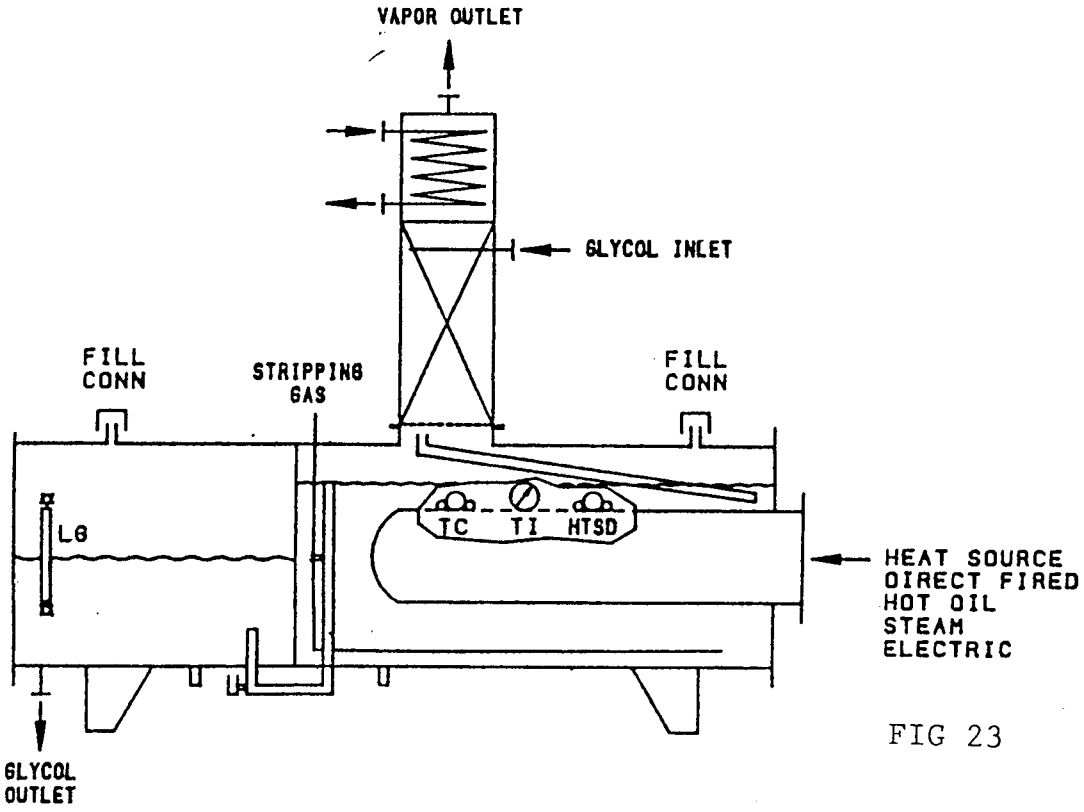


FIG 23

GLYCOL REBOILER WITH INTEGRAL SURGE

TEMPERATURE	- 350° to 400°F.
PRESSURE	- Atmospheric to 1 lb. unless otherwise designed.
LIQUID LEVEL	- Over heat source.
FLOW RATE	- As calculated for gas volumn and conditions.

temperature to lower the water content of the treated gas, and vice versa (see Appendix "G"). Most gas contracts only allow a maximum of 5 to 7 pounds of water per million cubic feet of gas. It is important to operate the reboiler at a temperature that will be sufficient to keep the water content under that specified by the gas contract. This temperature for your particular unit can only be determined by trial and error. However, in most cases, this minimum temperature will be somewhere in the range 350 - 375 degrees Fahrenheit.

Triethylene glycol boils at a temperature of 546 degrees Fahrenheit. However, T.E.G. begins to decompose at around 404 degrees Fahrenheit. This necessitates that the reboiler temperature never exceed 400 degrees Fahrenheit.

PRESSURE

Most reboilers are atmospheric vessels that will have only a few ounces vapor pressure on them at any given time. The variance in this pressure will not affect dehydration, however from a safety stand point reboilers should never exceed 5 psi. Over pressuring the reboiler could result in equipment damage and personnel injury.

Some reboilers are designed as pressure vessels usually in the 15 to 25 psi range. These vessels most often incorporate stripping gas through a Stahl column or blanket gas in the surge tank to prevent corrosion and glycol oxidation.

LIQUID LEVEL

The glycol level must be kept above the heat source in the reboiler to prevent premature failure of the heat tube(s). A fixed weir is incorporated into the reboiler to assure proper liquid level.

FLOWRATE

No limits for glycol flowrate through a reboiler are given. It must be noted, however, that excessive flow rate through the reboiler may result in too little retention time for the glycol to be effectively reconcentrated. A maximum recommended glycol flowrate through the reboiler is incorporated into the dehy units' design specifications.

THE STILL COLUMN AND REFLUX CONDENSER

TEMPERATURE

Temperature is critical to the operation of both the still column and the reflux condenser. Heat is provided by the reboiler. As perviously mentioned, the reboiler temperature is usually kept between 350 degrees Fahrenheit and 400 degrees Fahrenheit. Reboiler temperature in the range insures adequate heat transfer to the ceramic packing found in the still column. This

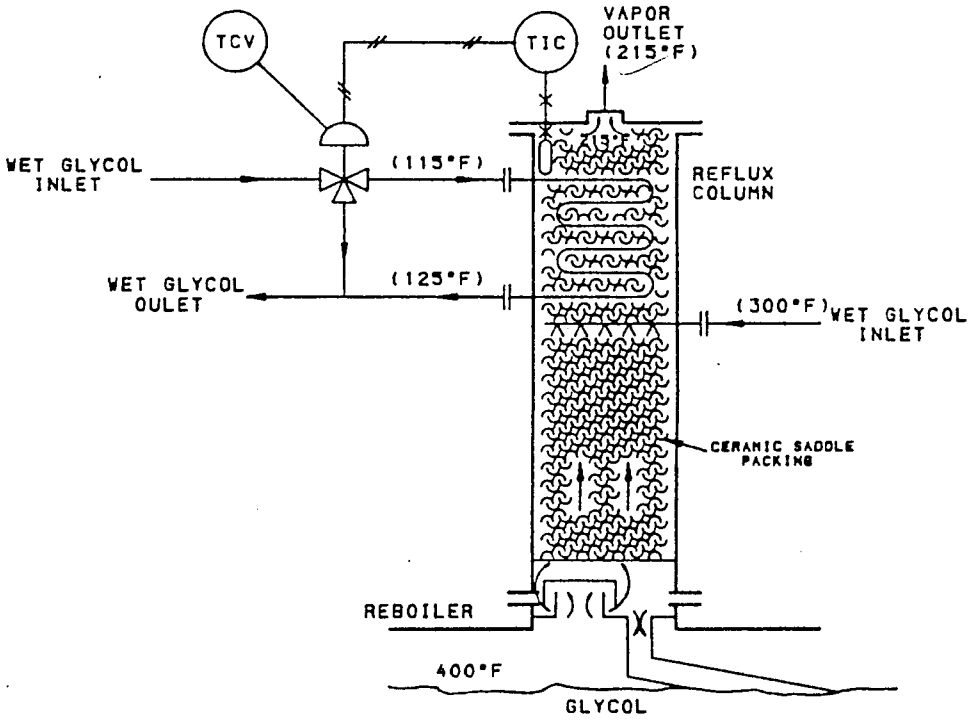


FIG 24a

STILL COLUMN

TEMPERATURE	- Vapor outlet at 215° to 225°F is Best.
PRESSURE	- Not to exceed 1 lb. unless otherwise designed.
LIQUID LEVEL	- None.
FLOW RATE	- Within design vapor pressure spec's.

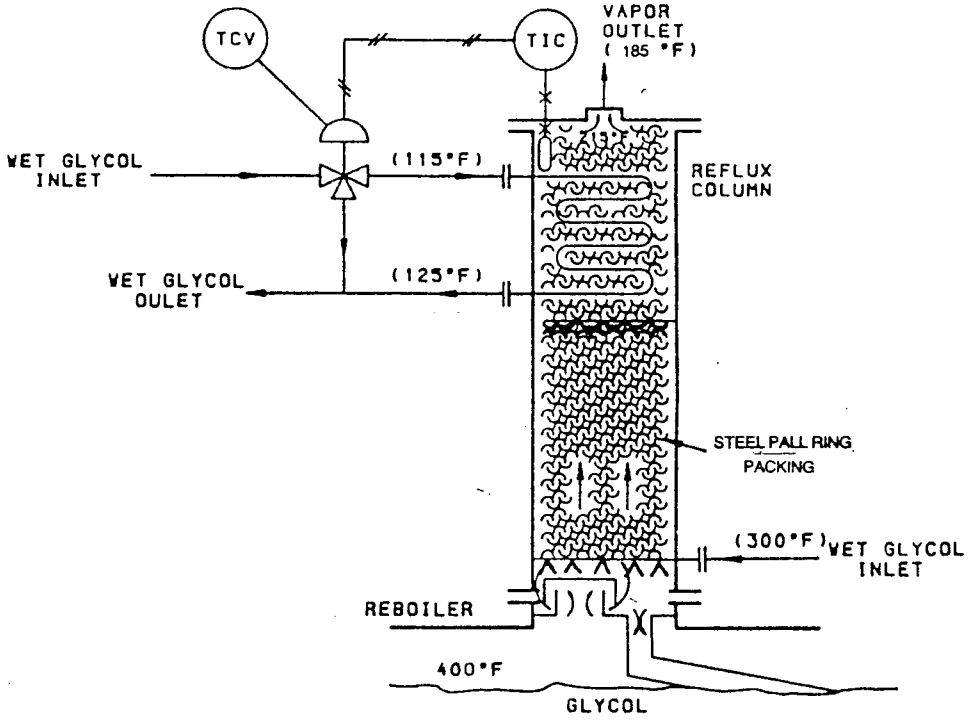


FIG 24b

REFLUX CONDENSER

TEMPERATURE	- Vapor outlet at 185° to 195°F is Best.
PRESSURE	- Not to exceed 1 lb. unless otherwise designed.
LIQUID LEVEL	- None.
FLOW RATE	- Within design vapor pressure spec's.

method of heat transfer is called convection. The still column operates best with a vapor outlet temperature of 215 degrees Fahreheit to 225 degrees Fahrenheit. Steam is easily allowed to escape. By design, the reflux condenser operates at a cooler temperature. The purpose of the still column is efficient use of available heat through distillation in the column. The reflux condenser solely prevents glycol loss due to vaporization. Hence, it is not unusual to effectively operate a reflux condenser with a vapor outlet temperature of 185 degrees Fahrenheit to 195 degrees Fahrenheit. This temperature allows a greater volumn of condensation by the reflux coil while still permitting the majority of the steam to escape.

Sometimes especially during cold weather, the reflux coils do their job too well and start to condense too much water in addition to the glycol vapors. When this happens, the reboiler has to work harder and sometimes just can't maintain the required temperature. There's a bypass valve with which you can bypass a portion of the cool glycol around the reflux coil if this situation arises.

PRESSURE

As an integral part of the reboiler, the reflux column operates at just a few ounces over atmospheric pressure. As long as the vapor outlet is not blocked and the packing not plugged or fouled it will not dangerously over pressure. Reflux columns are sized based on vapor pressure, or the volume of water expected to be distilled in relation to its expansion and removal.

LIQUID LEVEL

The reflux column is not designed to carry a liquid level and only does so during extreme system malfunction such as a plugged reboiler glycol outlet or glycol saturation.

FLOWRATE

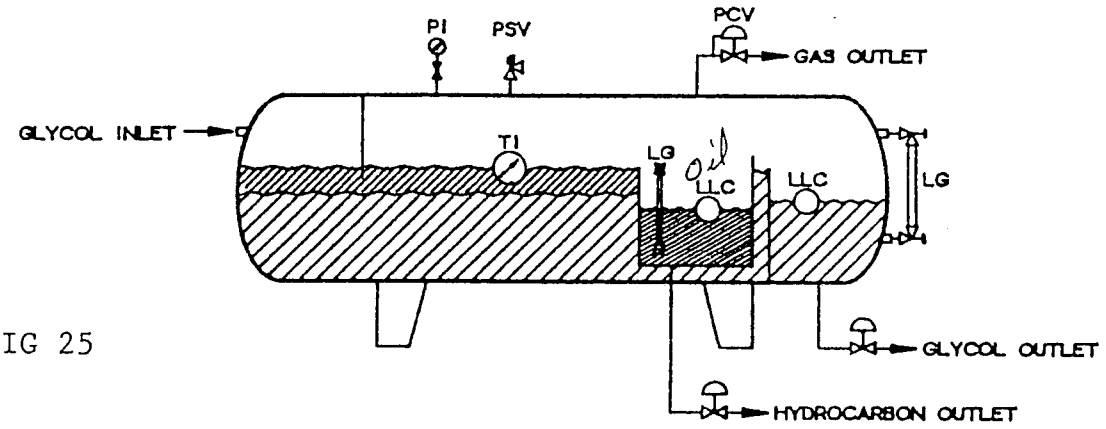
The range of vapor flowrate is predetermined by the engineer when sizing the reflux column. Excess vapor flowrate can only occur during periods of glycol saturation.

THE GAS—CONDENSATE—GLYCOL SEPARATOR

TEMPERATURE

The temperature of the GCG separator should generally run between 100 degrees Fahrenheit and 150 degrees Fahrenheit. Heat aids in the separation of hydrocarbons from the glycol. Too much heat, usually temperatures above 170 degrees Fahrenheit, may result in the loss of liquid condensate (light end hydrocarbons) to vaporization. Some units have a by-pass around a portion of the heat exchangers to help control skimmer temperature.

FIG 25



GLYCOL HYDROCARBON SKIMMER

TEMPERATURE - 100° to 150°F is Best.

PRESSURE - 50 to 75 lbs. is Best.

LIQUID LEVEL - Midway each level gauge.

FLOW RATE - Within design spec's.

PRESSURE

The pressure of the gas-condensate-glycol separator is not very critical but should be controlled between 50 and 75 pounds. This will insure sufficient pressure to move the glycol and liquid hydrocarbons from the skimmer through the remainder of the unit. If a lower skimmer pressure is able to safely move the liquid, then operate at the lower pressure. The lower pressure will allow greater gas breakout from the glycol. Be cautious. Too low a skimmer pressure may result in glycol loss through carry over.

If there isn't enough gas in the wet glycol coming into the vessel to hold this pressure, then makeup gas will have to be piped in. Most units come equipped with connections to do this.

LIQUID LEVELS

Since the horizontal separator performs its job through the use of weirs, it's very important that the liquid levels of each compartment be maintained properly by the level controllers. These levels are set during initial startup and should be kept about midway of each gauge column.

The vertical separator may use weirs and buckets similar to a horizontal separator but more commonly relies on an interphase controller. An interphase is the horizontal plane formed by two liquids which do not mix, such as wet glycol and oil. The interphase controller senses the lower, denser liquid only while a second controller located above the interphase controller senses the lighter liquid on top. The hydrocarbon condensate (lighter liquid) should be kept about midway of the upper gauge glass while the glycol-hydrocarbon interphase should be kept about midway of the lower gauge glass.

FLOWRATE

The glycol flowrate through the G-C-G separator should be kept within the design specification provided with the vessel. Excessive flow through the skimmer may lead to poor separation due to insufficient retention time or possibly liquid carryover.

HEAT EXCHANGERS

TEMPERATURE

Heat exchanger temperatures will vary from unit to unit. The range of temperature, though critical to the process, is not critical to the heat exchanger as long as the design specifications are not exceeded. For units whose heat exchangers provide glycol suction to a glycol-gas powered pump, the temperature of the exchanger at its dry glycol outlet should not exceed 200 degrees Fahrenheit as specified by some pump manufacturers.

PRESSURE Heat exchangers are designed and constructed for various pressures with relation to different processes. Most commonly, on glycol units, the wet glycol side of a glycol to glycol exchanger will be governed by the pressure of the glycol-hydrocarbon separator and/or the head pressure of the wet glycol entering the still column. This pressure should not exceed design specifications.

LIQUID LEVELS

Although not apparent, liquid levels within heat exchangers are an important factor in their operation. In most cases, dry glycol must gravity feed through the exchanger from the reboiler/surge tank to the glycol pump. The positioning of the exchanger to allow dry glycol to fill fully the entire exchanger is critical to maximize heat exchange.

FLOWRATE

Flow is extremely important to heat exchange. The faster the flow through the exchanger, the more efficient the heat exchange. This principle is known as turbulent flow. Maximum heat exchange efficiency is the result of the greater temperature differential across the common wall of the exchanger. Flow through the exchanger is considered and allowed for when the system is designed. It is the operators responsibility to insure that the exchangers are clean to permit this flow to occur. As previously mentioned, in most cases the dry glycol gravitates through the exchanger. Build-ups in the exchanger may reduce the dry glycol flow thereby reducing the efficiency of the exchanger.

STRAINERS AND FILTERS

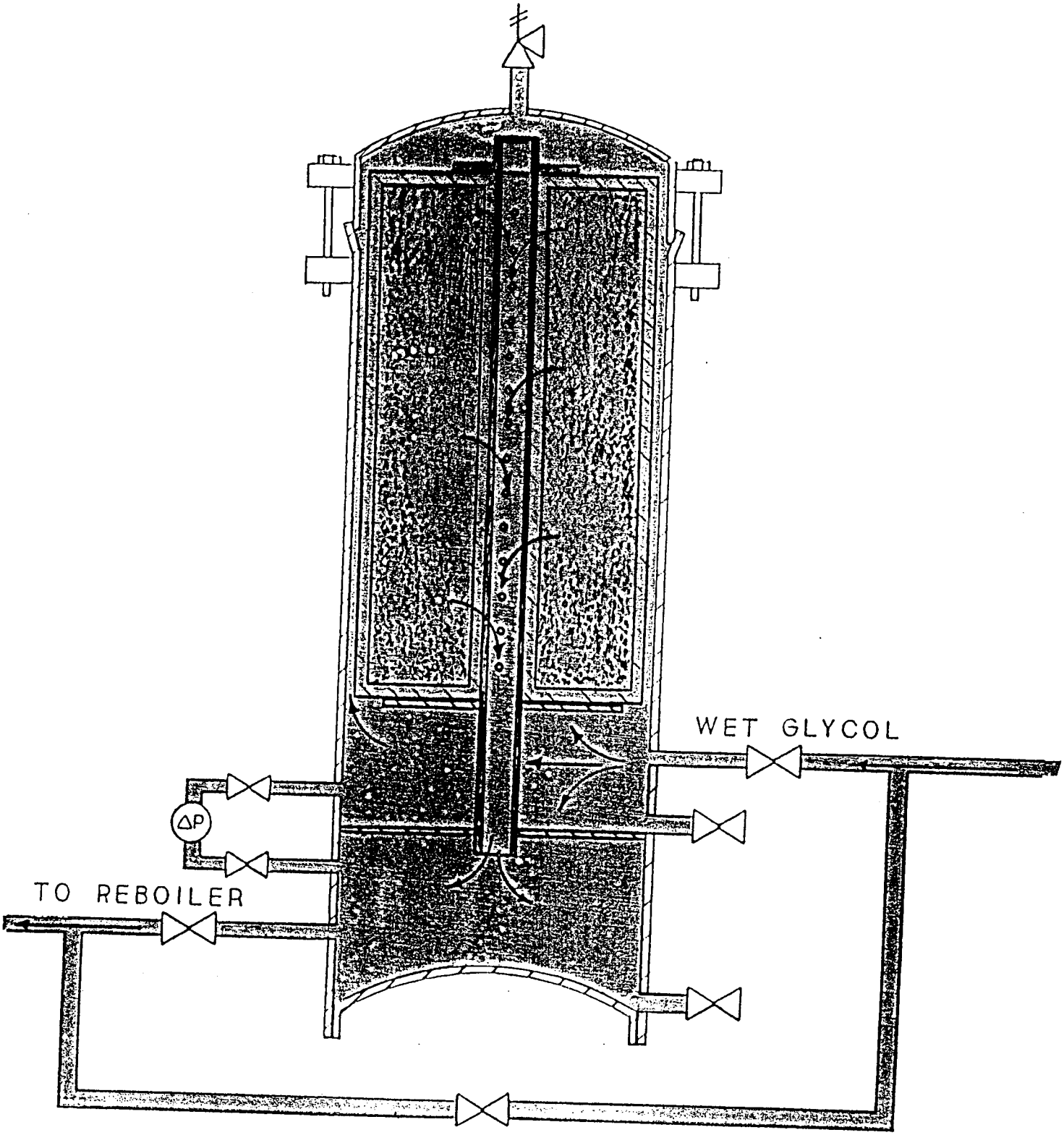
TEMPERATURE

Temperature does not effect the operation of the filters or strainers as long as design specifications are not exceeded. Usually, the design temperature of a filter or strainer is limited by its gasket or seal. Most commonly, manufacturers limit the recommended operating temperature to 250 degrees Fahrenheit or less.

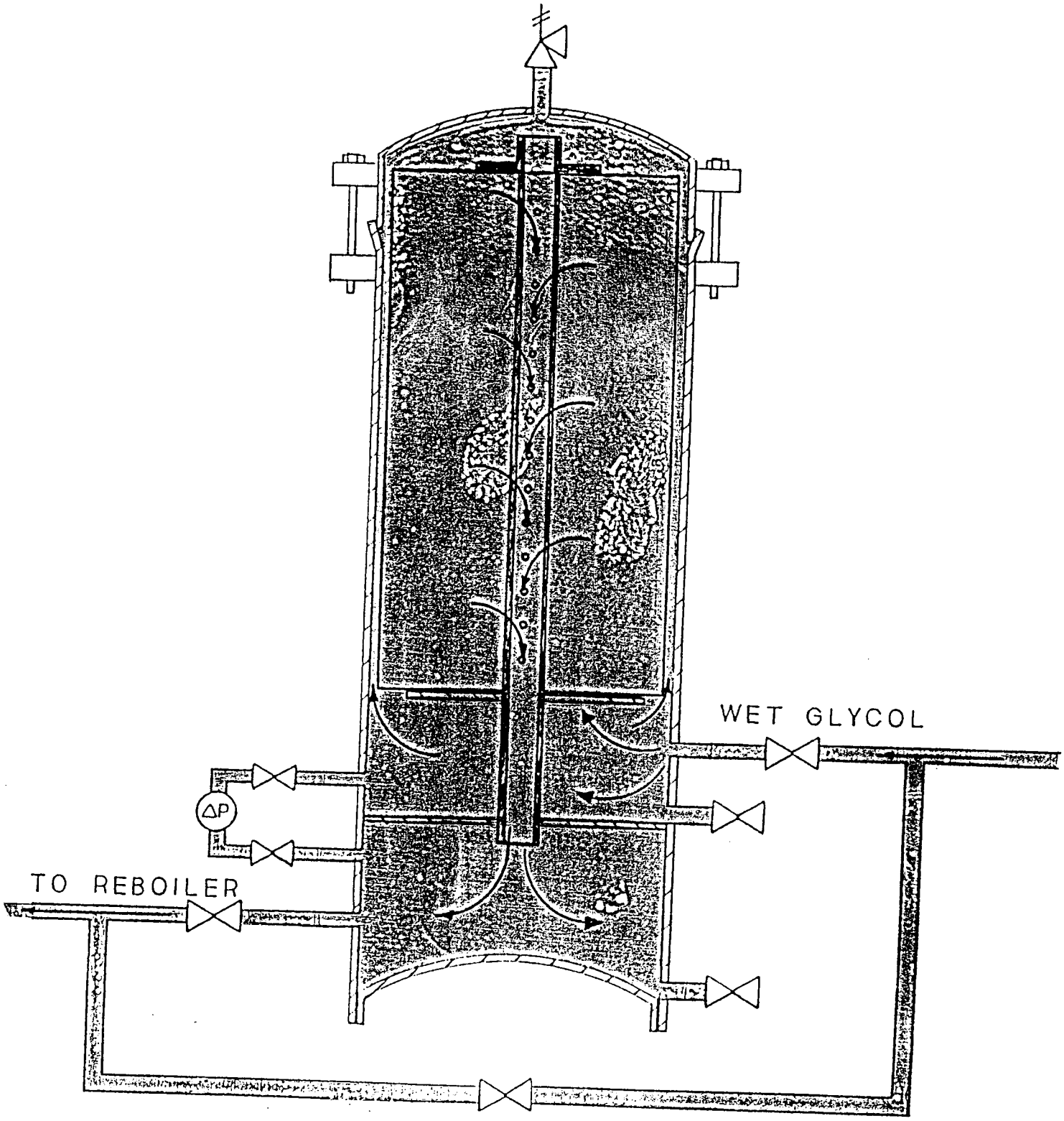
PRESSURE

Filters and strainers are limited by design pressure and differential pressure. Unit construction dictates design pressure. As long as pressure specifications are not exceeded design pressure is not a problem for the operator. Differential pressure, however, requires monitoring. Differential pressure is the difference in pressure upstream and downstream of the filter or strainer element. Differential pressure is a function, in this case, of how contaminated the filter or strainer element may be. High differential pressure indicates dirty or clogged elements and necessitates cleaning or replacement. Differential pressure for sock

CHARCOAL FILTER



SOCK FILTER



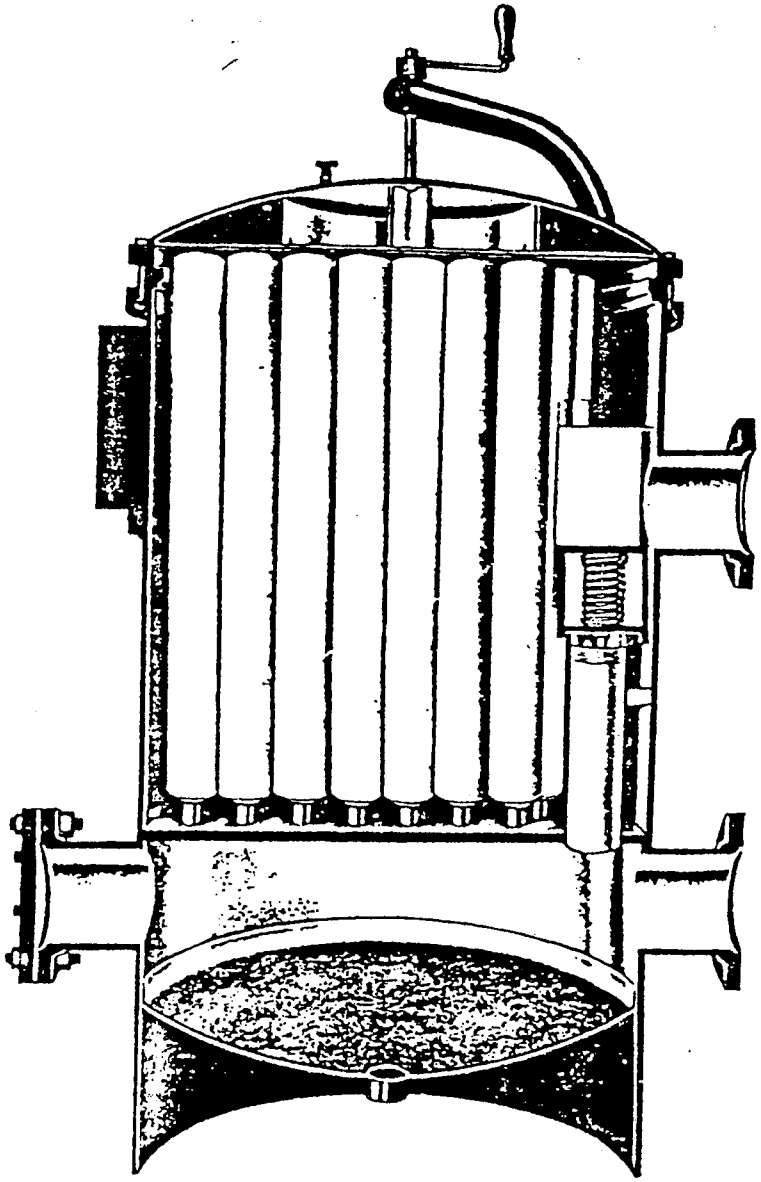


FIG 26

TEMPERATURE - Within design spec's.

PRESSURE - Within design spec's.

LIQUID LEVEL - Over filter elements or media.

FLOW RATE - Within design spec's.

type filters should not exceed 15 PSI. Differential pressure for carbon filters and high pressure strainers should not exceed 1 to 3 PSI. Low pressure strainers should not show any differential pressure when used in glycol lines that gravity flow.

LIQUID LEVEL

To insure maximum efficiency of a filter or strainer, the vessel (or component) should be fluid packed. Often, a gas head forms in filter cannisters preventing use of the entire filtering surface. To prevent this the filter cannisters should be piped immediately following the glycol hydrocarbon separator on units that incorporate one. The glycol dump valve should be placed on units that incorporate one. The glycol dump valve should be placed on the glycol line downstream of the filter cannisters. Once flow is established, the existing gas head should be bled off of each filter. On units that do not have a skimmer or two phase flash tank to eliminate gas from the glycol stream it will be necessary to bleed the gas head off the filter cannisters once or twice daily.

FLOWRATE

All filters will be rated for maximum flowrate desired. The maximum flowrate is determined by the filter size, pressure rating, and filtering media. The design flowrate should not be exceeded. Strainers also may be rated for a maximum flowrate (see Appendix "H").

SURGE TANK (ACCUMULATOR)

TEMPERATURE

Surge tank temperature is dictated by the surge location in the flow scheme. If the surge tank is an integral part of the reboiler vessel or if the surge is immediately downstream of the reboiler, the temperature will be governed by the reboiler temperature. In this configuration the surge temperature may range form 5 degrees to 50 degrees cooler than the reboiler. On units where glycol powered pumps are used, and the surge is a separate vessel with internal heat exchangers or when heat exchangers are separate form the unit, the temperature of the glycol leaving the surge tank or the exchangers should not exceed 200 degrees Fahrenheit. This is to protect the glycol pumps.

PRESSURE

Unless the reconcentrator is designed to be pressurized (as in the case with units designed for blanket gas) the surge tank should operate at atmospheric pressure. Any pressure, however slight, may adversely effect glycol flow from the reboiler. The surge tank should be opened to atmosphere through a small vent port or needle valve. Otherwise a slight vacuum on the surge tank may result from glycol pump operation. This could cause pump

cavitation or poor pump performance.

LIQUID LEVEL

The surge tank should be kept ½ to ⅔ full during normal operation. This level allows room for expansion of cool replacement glycol added to the system. If the surge is equipped with coil type or tube bundle type heat exchanger it is usually located in the lower portion of the surge. Maintaining the surge level at ½ to ⅔ full will usually completely emerse the exchangers. This amount of glycol kept in the surge tank also allows retention time for the glycol cooling process to begin.

FLOWRATE

Flowrate through the surge is determined by the design rate of the reboiler. As long as the glycol pumps are sized for the dehydration system capacity, flowrate will not be a problem.

GLYCOL PUMPS

TEMPERATURE

Electric piston type pumps are usually rated for temperatures up to 650 degrees Fahrenheit: Special applications may increase that temperature (see Appendix "F").

"Kimray' glycol-gas powered pumps are limited to a maximum of 200 degrees Fahrenheit on the dry glycol suction to the pump (see Appendix "D") when using standard Buna-N type o-rings.

"Glyrotor" glycol-gas powered pumps can be special ordered for up to 400 degrees Fahrenheit service (see Appendix "E").

PRESSURE

Glycol-gas powered pumps for most systems are limited by construction to 1500 PSI working pressure. Lower pressure ratings may apply to pumps designed for systems with lower working pressures.

Electric piston pumps may be rated for pressures as high as 10,000 PSI.

In all cases, the design working pressure should not be exceeded.

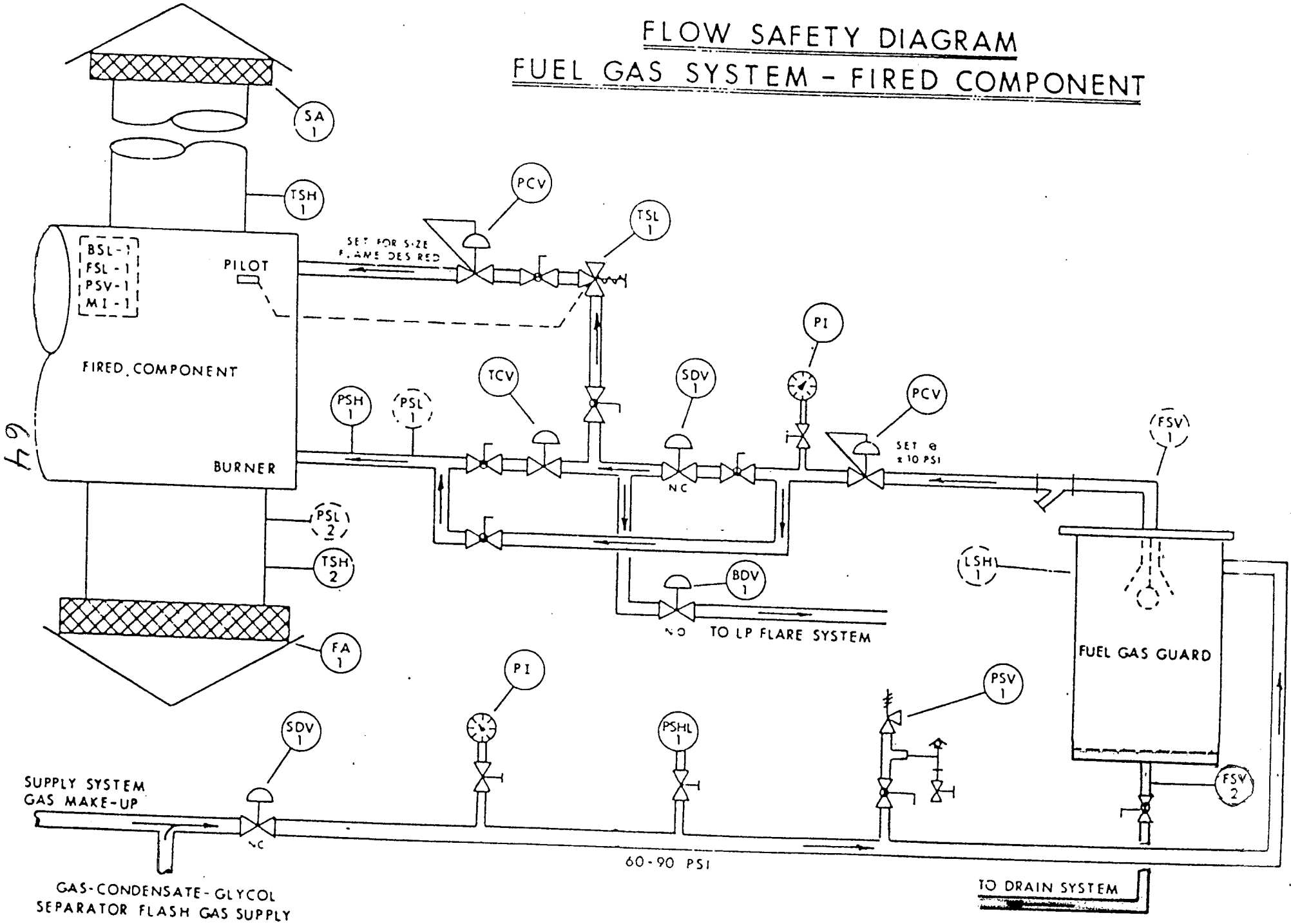
LIQUID LEVEL

Liquid level is not applicable to the glycol pump, however liquid levels upstream of the pump should be maintained at such a level so as to provide positive pressure at the pump suction.

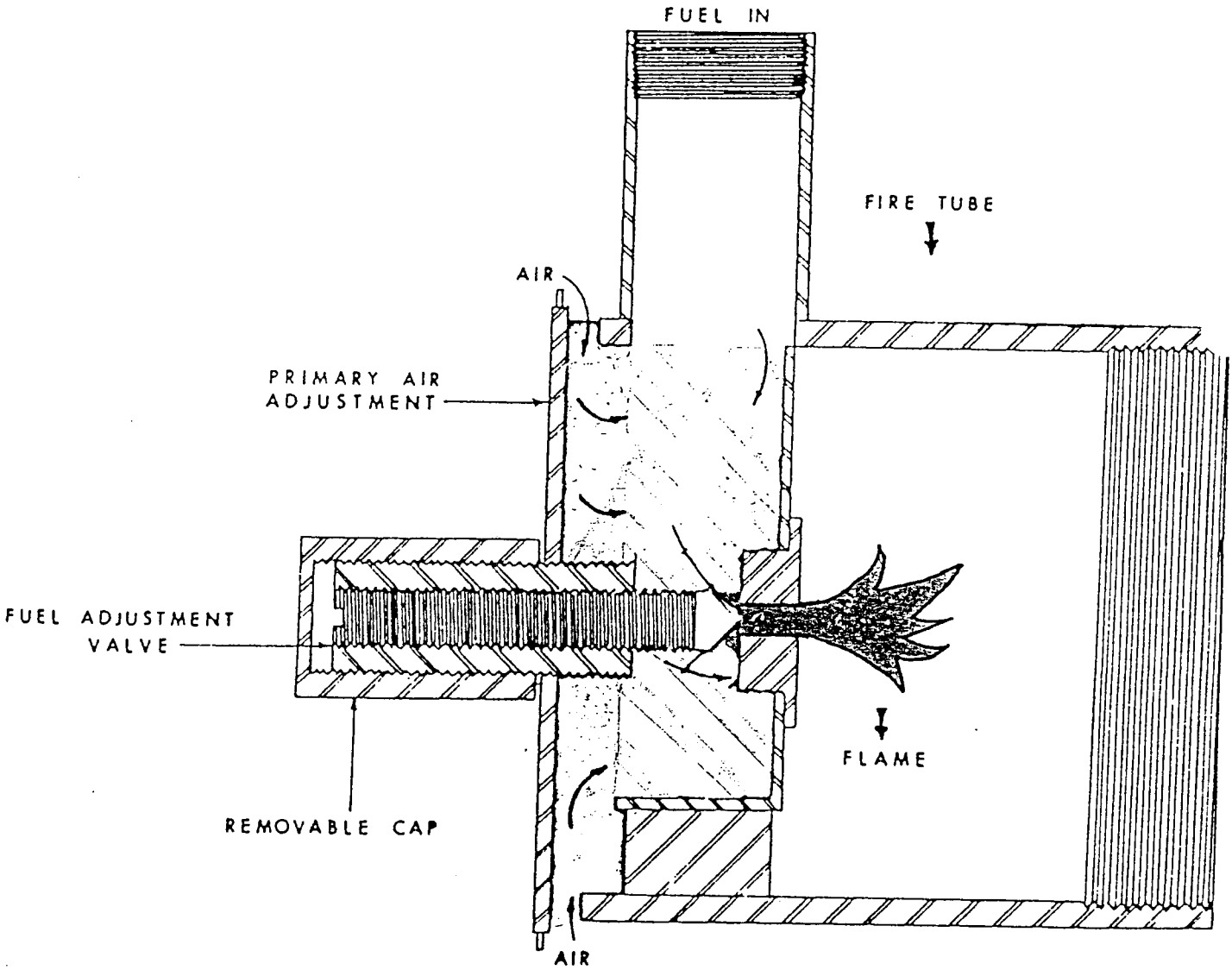
FLOWRATE

Maximum pump flowrate will be determined by the pump design. Flow rate may be adjusted accordingly based on process needs. Determining glycol circulation rates will be given elsewhere in the manual (see Appendix "K").

FLOW SAFETY DIAGRAM
FUEL GAS SYSTEM - FIRED COMPONENT



BURNER ASSEMBLY



Glycol Dehydration

Unit III

Unit Start-Up
&
Shutdown

GLYCOL DEHYDRATION
NEW FACILITY
POST INSTALLATION INSPECTION, SERVICING AND STARTUP PROCEDURES

A GENERIC EXAMPLE OF TYPICAL GLYCOL SYSTEMS. NOT INTENDED TO BE AN "ALL" INCLUSIVE EXAMPLE.

- PRE-SERVICING PROCEDURES

Service technicians/representatives should familiarize themselves with the literature for all the instruments and controls. Study drawings and flow sheets related to the system. Perform a walk-through inspection of the system looking for obvious problems.

- POST INSTALLATION INSPECTION CHECKLIST

- Are control components installed and connected properly?
- Are all regulators that are required provided and installed properly? Verify inlet and outlet connection orientations.
- Are block valves missing? Are block valves properly installed?
- Are the right type of controls used?
- Is piping properly completed?
- Are pumps installed (positioned, leveled), aligned and piped properly?
- Are there any missing accessories? Are all accessories installed properly?
- Are Flow Safety Valve's (Check valves) inlet and outlet flow connections installed properly? Check "Wafer" type very careful.

- Are all vessel Level Controllers installed properly?

- Are there any unfamiliar items installed on the system? Acquire information for the unfamiliar items and understand their usage and maintenance requirements. Review project manuals.

- Plan for the servicing of electric pumps as required by manufacturer. Verify alignment requirements, etc.

- PRE-SERVICE PARTS CHECKLIST

1. Make a checklist of items and materials required for the job. Use the work order if appropriate. By using the work order, the site personnel will have a permanent record.
2. Discuss the job scope with the customer or facility supervisor. **Use the Job Safety Analysis for work related activities. Conduct all activity within the framework of the Job Safety Analysis.**
3. Check delivery times for critical parts not yet installed. Communicate with facility Purchasing Agent as necessary. A rush order status may be required to receive parts and components (in a timely manner) to complete the job on schedule. Receive acknowledgement or confirmation of delivery.
4. Keep the client management members or Facility Supervisor aware of any major delays (delivery problems) of required parts (as they become known).

SERVICING THE DEHYDRATION UNIT

- LEVEL CONTROL CHECKLIST

- Check the Level Control displacer (float), torque tube, etc. Examine: If its an interface liquid Level Control it will usually take a special size float. Install any Displacers (floats) that were shipped loose.

- Is the **Level Control a right or left hand mount unit**? Which should it be? Insure the mounting is correct for the application.

- Check the snap or throttle action of all level controls, for proper operation.

- Level Controllers, such as the Fisher 2500 series, use Bourdon Tubes. Check the pressure range (rating) of the Bourdon Tube. It should match the Level Control (dump) Valve spring range, 3-15 PSI or 6-30 PSI.

- Check each Level Control assembly for the proper float position, (horizontal or vertical).

- Check the float operating range. Should be mid-range in the Gauge Column or Sight Glass.

- Check the Level Safety High and Level Safety Low control positions.

- If there are any electrical/electronic Level Controllers or associated valves, review the manufacturer's manual for service instructions.

- Complete all instrumentation control tubing, etc needed for operation of the units.

- Prepare and implement the instrument test plan.

- DIAPHRAM CONTROL VALVE CHECKS

- Check the control valves, to assure they are correct for the service application.

- Check the control valve's trim size. See the manufacturer's manual for flow rates, etc.

- Check the valve operator action. Is a **Normally Open** or **Normally Closed** control assembly required?

- Check the valve spring/operating pressure range requirements.

- Are the control valves installed correctly (Inlet/Outlet connections) for proper flow direction?

- SAFETY SYSTEM CHECKLIST

- Check the **T**emperature **S**afety **H**igh installed in the heated media.

- Check the **T**emperature **S**afety **H**igh in the stack (temperature range should not exceed 900°F).

- Check the **B**urner **S**afety **L**ow installation. Is it Electrical or Pneumatic?

- Check the **L**evel **S**afety **L**ow and **L**evel **S**afety **H**igh. Examine Level Safety modes and positions. Are the controls installed correctly (too high or low)?

- Check all **P**ressure **S**afety **V**alves (Relief) discharge (Outlet connection) orientations and Pressure Settings.

- Visually inspect instrumentation for correctness and completeness. Look for insect nesting and plugging in exhaust ports or vent holes.

- NATURAL DRAFT BURNER CHECKS

- Perform a visual inspection of the fire tube burner and pilot positions.

- Is the air-gas mixer's Adjusting Screw or other components frozen or able to move freely? Examine.

- Does the burner assembly extend into the fire tube properly?

- Is the Flame Arrestor clean and free of particles? Are all bolts tightened properly?

- GLYCOL HYDROCARBON SEPARATOR CHECKS

- Insure Adjustable Weir is installed correctly. Measure the oil spill over weir. Adjust the glycol weir setting to 1" below the oil spill over weir.

- EQUIPMENT HYDROTESTING STARTUP

- If the equipment is going to be, or has been tested with water pressure, **drain** all water from the equipment, fuel gas system, and piping, after the testing. Water is easily over looked and will cause major problems during startup of the dehydration unit. Note: The Reboiler could take over 24 hours to boil off this test water and reach the proper operating temperature.

- ADDING GLYCOL IN THE SYSTEM

- Check all valves and openings in the system. Be sure they are in the correct position.

- To avoid spillage, plug any open connection, before filling the Reboiler and Surge Tank.

- Fill the Reboiler with glycol first. The level in the Reboiler will spill over into the Surge Tank. Fill Surge Tank next, but no more than half full of glycol.

- Fill the 3-phase Gas-Glycol-Condensate Separator (Skimmer) through its front connection until the glycol is seen rising in the glycol section of the Separator.

- Wait to fill the glycol Contact Tower trays with glycol, until after it has been tested, purged, and drained of water. After the Contact Tower is depressurized, remove the tray drain plugs to drain the water from the trays. Wrap the N.P.T. plug connections with Teflon tape, reinstall and tighten the plugs properly.

- Using a **low flow rate**, begin filling the Contact Tower's Bubble Cap trays or internal assembly. DO NOT OVER FILL. Verify level in the Gauge Column or Sight Glass.

- If unable to drain the water from the Bubble Cap trays follow these steps: 1. Disconnect the glycol tower outlet line downstream of a block valve. 2. Open the glycol outlet valve to let the displaced water flow out of the tower as it is filled with glycol. IMPORTANT: Do not pump more glycol in than the amount of water removed.

- Monitor the water coming out of the glycol outlet line with a bare hand until a mixture of water and glycol is coming out of the line, (it will feel slick). When you feel the slick mixture, stop pumping glycol into the tower.

- Close the glycol outlet valve and install the glycol outlet piping.

- If the Contact Tower is large, it is worth the effort to fill the Tower Bubble Cap trays before startup. This will significantly cut down the startup time and wear on the pumps.

- Always look for glycol leaks as each component is filled. Glycol is expensive, and accidental loses could delay a startup operation due to glycol shortages.

- On small glycol dehydration units, the Contact Tower is usually filled directly by the KIMRAY pump, since it only takes a small amount of glycol to reach the appropriate level required in the Contact Tower.

- If the system is equipped with electric pumps, inspect/service the pumps per the manufacturer's specifications, before use. The Contact Tower will have a Level Controller and a Level Control (dump) Valve that returns the glycol to the Reboiler. Note: With an electric pumping system pre-charging the system, use of another pump before normal startup operation is not required. Adjusting (servicing) and setting of the Level Controls will be required.

CAUTION: **STOP FILLING** THE GLYCOL TOWER WHEN A LIQUID LEVEL IS SEEN SIGHT GLASS (IN THE TOWER GLYCOL BOTTOM SECTION). SYSTEM PRESSURE IS USED TO DISCHARGE (DUMP) THE GLYCOL OUT OF THE TOWER.

- FILTER UNIT SERVICING

- Open all the filter housings and check for filter elements installation. If elements are missing, install the proper elements.

NOTE: MANY TIMES EXTRA FILTERS ARE NEEDED DURING STARTUP. Check to see that Filter spares are in stock or on order.

- BTEX UNIT (HAZARDOUS WASTE REMOVAL)

- BTEX units are used on most if not all glycol units to remove the hazardous air pollutants. Triethylene glycol (TEG) has a strong affinity for water, but it also readily absorbs Benzene, Toluene, Ethylbenzene and Xylene (BTEX) and other aromatic hydrocarbons that may be present in the gas stream. Certain laws require the removal of BTEX without their release into the surrounding air. **Insure all areas of the operations comply with EPA and other regulations**.

LEVEL CONTROL CHECK (for BTEX Units)

- NOTE—Check the float material utilized in the system. Due to the potential of excess heat build-up in the Reboiler (Reconcentrator) system, NATCO uses a stainless steel float. BTEX temperatures may get excessive for some plastic or composite materials.

- Certain types Floats may fall off the Lower Level Control rod due to excess heat.

- Check the pump's Level Control to insure it is snap acting.

- GLYCOL PUMP CHECKLIST

- If the pump is a double diaphragm pump, install a **F**low **S**afety **V**alve (check valve) on the discharge piping to stop fluid from backing up through the unit.

- Examine, inspect the Strainers and Lubricators on the pump supply gas inlet. If they are not installed, install them. Note, some pumps don't require Lubricators, although the majority of pressure-operated pumps.

- Examine and insure that all pump supply gas systems or pneumatic pressure systems have liquid traps with drain valves.

- The Pump's, liquid suction line, should have a Strainer installed. Install a proper pressure rated Strainer if there is none.

-

- BTEX HEAT EXCHANGER CHECKS

- Inspect the heat exchanger unit for any damage.

- The steam inlet line should be installed sloping down to the cooling coils of the heat exchanger.

- GAS VENT HOOKUP

- Check the BTEX gas vent outlet hookup, with the drawings. Is it connected properly?

- Vent gas is usually burned inside the Reboiler's fire-tube or in a flare stack system.

- ACCESSORIES

- Install the miscellaneous accessories for the unit.

- DEHYDRATION EQUIPMENT STARTUP

- The glycol Contact Tower should be pressured up to sales line pressure and fuel gas made available.
- Close the block valves to the Burner and Pilot Light assemblies on the Reboiler.
- Do a walk through inspection, checking the components, pressure, fuel gas system and other systems.
- Drain any trapped water.
- Close the valves to the Glycol Pumps.
- Add makeup gas on the Gas-Glycol-Condensate Separator to about 60 PSI.
- Set the Gas-Glycol-Condensate Separator's **Back Pressure Control Valve to relieve (exhaust pressure) at about 70 PSI.**
- Adjust Regulators to supply instrument pressure to all the controls.
- Set and test each control for proper operation.
- Preset all the Level Controls with a dry float set.
- Test the safety system components for proper operation. Observe for proper output where required.
- Close the Gas-Glycol-Condensate Separator's oil Level Control Valve (dump) outlet line to prevent glycol loss.
- Open the oil outlet line of the Gas-Glycol-Condensate Separator for normal operation, after completion of startup. At the customer's option it may keep it closed, and the hydrocarbons can be discharged manually. Note: There should never be large amounts of hydrocarbons produced in this unit.

- After a five minute minimum purge of the burner and pilot assemblies, prepare the burner system for startup. NATURAL GAS THAT IS NOT COMPLETELY FREE OF AIR, WILL NOT LIGHT (BURN PROPERLY), CAUSE PILOT FLAME FAILURE OR BURN BACKS (BLOWOUTS).

- Adjust the Temperature Controller to gain output that opens the Burner's (TCV) fuel valve.

- Open the Pilot Gas block valve, and using the ignition system, ignite the pilot.

- After the **B**urner **S**afety **L**ow (BSL) operation has been established, open the main Burner block valve (very slowly) to ignite burner head.

- Adjust the Burner Air/Gas mixer as needed, to produce the proper burning flame.

- Monitor the increasing temperature on the Reboiler, and MAKING SURE THE PUMP HAS BEEN PRIMED AND IS RECEIVING GLYCOL FROM THE SURGE TANK. Start the glycol pump with a low rate of circulation until glycol from the Tower has returned.

- Watch the pressure on the Gas-Glycol-Condensate Separator since it will be receiving gas pressure from the Contact Tower. Adjust the Back-Pressure Valve's controller accordingly (to the proper pressure for normal operation).

- Watch the pump circulation to assure glycol fluid flow from the Contact Tower. The KIMRAY pump may stop stroking or the strokes will slow down. The glycol return line from the Contact Tower will experience an increase in temperature (warm up) when wet glycol starts flowing or is returning.

- Add glycol in the Surge Tank only after the level decreases too low or as required. Keep the Surge Tank one-third to one-half full, no

more at this time. Once heated the glycol will expand in volume. Watch this level closely.

- **If glycol begins to over-flow from the Surge Tank:** Drain some from the cool wet stream into an empty drum or container. It can be added to Surge Tank later.

- Observe the system and correct leaks if they occur as the heated glycol flows through the system. Normal thermal expansion can cause leaks to occur as the components experience a gain in operating temperature.

- Observe the Gas-Glycol-Condensate Separator liquid levels and pressure. Adjust as necessary.

- Fill Filter/Filtration vessels slowly. Open Bleed valves to discharge or vent air trapped from inside the vessel. Whenever the Differential Pressure Indicator (DPI) is 15 PSI or greater, a filter change is required.

- Observe the Reboiler temperature frequently to make necessary adjustments.

- Do a visual overall inspection of the unit for any obvious problems. If you don't see any other problem occurring, continue to examine the entire system. REMEMBER MURPHY'S LAW! Always have a heighten sense of awareness (stay on guard) when starting up any piece of equipment, **catch potential problems early** or at their inception.

- Watch the steam outlet of the Reboiler as the temperature increases. If there is a heavy steam content, this indicates that water may be trapped in the Contact Tower or elsewhere within the system. Many times, new systems are saturated with water. It can be due to trapped water that has not been properly removed until start-up operation.

- Important: New Glycol units may develop a severe steam breakout, (excessive flow velocities) causing hot glycol liquids to

blow out of the Still Column. These cases of excessive steam velocities are occur due to the excessive amount of water saturating the glycol as described above. Steam breakout typically occurs whenever the Reboiler's operating temperature first reaches 225°F to 325°F.

- To control the excessive steam production, control (slow down) the Burner fire rate. Lowering the Burner's flame intensity to lower the BTUs, will result in vaporizing less water.

  Note: If a glycol blowout occurs, turn off the Burner and stop the glycol circulation pumps. After the steam production diminishes to normal, restart the Burner at a lower intensity and slowly increase the pump flow rate. Monitor the steam output and limit the heat input to the Reboiler if necessary once again. The steam quantity will decrease over-time. This will in turn allow for an increase the Reboiler's temperature and a return to normal operation.

- When the Reboiler reaches the desired operating temperature (375-380 degrees F), observe and adjust the Temperature Controller if necessary. If a Temperature Safety High (TSH) is installed, adjust to a maximum of 400°F.

- Let the Reboiler cool down below the operating temperature, and observe the Temperature Controller for proper operation.

- Set the glycol Pump rate according to the recommended strokes required for the amount of water to be removed. Increase the pump stroke rate appropriately if gas flow rate is increased.

- Adjust the Burner air/gas mixer and the fuel gas pressure according to BTU requirements of the Reboiler.

- Adjust the safety system controls (finalize the setting on each component) according to normal operation requirements.

- FINAL OBSERVATIONS BEFORE GAS DEHYDRATING

- Is the Reboiler operating at the proper temperature?
- Does the steam quantity appear normal (with little steam coming out)?
- Is the pump rate set properly?
- Is the glycol system working properly?
- Examine each aspect of the total dehydration system once more.
- The glycol unit is ready for natural gas stream flow into the Contact Tower.

GAS DEHYDRATING

- Open the outlet valve of the Contact Tower first. Open the Inlet Valve very slowly. Close the By-pass Valve very gradually. "Going Slow" with this operating phase is very important.

- MONITORING THE DEHYDRATION SYSTEM

- Make a listing of all the points to be monitored. All operating conditions must be checked and observed continuously for the next 12 to 24 hours. A listing (proper record keeping) will help eliminate questions about conditions (as they previously were) as time passes. Having recorded the conditions also helps to call attention to obvious problems that you may not notice, without the records. Always write the monitored conditions down as you check the system, list the essential temperatures, pressures, pump strokes, gas rates, etc.
- Suggestion: Monitor the unit constantly for the first three (3) hours. If there are no problems, monitor periodically, on the half hour, for another three (3) hours. If no problems, go to a one (1)

hour inspection intervals or stay at the half hour schedule. If problems do occur, go to a constant attendance watch until the unit operates properly again.

- Note: Monitoring the dehydration system will vary from facility to facility. Most units that operate for 24 hours with little or no problems will tend to be ready for the routine daily inspection thereafter.

- DEW POINT TESTING (By Facility Operators)

- The Dew Point testing valve location should be predetermined and have a "sample cock" valve installed during the initial installation of the system components. Test the gas as close to the Contact Tower's outlet piping as possible. The test should be from a Needle Valve either in a vertical run or on top of a horizontal run of pipe. First, discharge gas from the needle valve to clean it.

- **NOTE: DO NOT TEST FROM A BOTTOM CONNECTION IN A HORIZONTAL RUN OF PIPE. LIQUID USUALLY CONDENSES OR COLLECTS HERE.**

- The Dew Point test should be done when the dehydration unit has worked properly for a minimum of 2 hours, providing all settings and operation aspects are correct or within design parameters.

- One common method of testing Dew Point is with a Sensidyne/Gastec gas detection system. It is inexpensive, very reliable and easy to use.

- **Suggestion:** Use the seven (7) pound water vapor tubes. These tubes come with the tester that includes instructions on how to use them.

- A three (3) inch or four (4) inch diameter stainless steel sample ball with venting holes in it and a ¼" National Pipe Thread (N.P.T.) nipple, welded to the ball, which is used to screw the

sample ball onto the gas test valve. The ball has one hole large enough to receive the seven (7) pound water vapor tube.

- Always vent gas through the gas Dew Point test connection to clean any contaminants before installing the sample ball. A small gas bleed is allowed for the dew point testing.

- Allow just enough gas out of the valve to have dry gas vapor fill the Ball. Do not vent excessive gas to create pressure in the Ball, but just enough to eliminate any air in the Sample Ball.

- Proceed with the Dew Point test instrument's instructions. Insert the test tube into the Sample Ball and perform the Dew Point test.

- The water content of the gas is read from the purple color reading in the tube. NOTE: The blue-green color in the tube is not water. The blue-green color is caused by gas contaminants such as hydrocarbons, or entrained glycol. For precise details, read the instructions in the gas testing (Sensidyne Tester) section of the dehydration manual.

- The Dew Point test should be good. If the Dew Point is high, check the system settings over once again. If you can't identify the problem, wait one (1) hour and recheck the Dew Point. **Operating Note:** Letting the glycol unit attain its normal operating status would be best.

- EASY STARTUP TIPS

- Increase the pump flow rate by two or three strokes.

- Increase the Reboiler temperature by 5 to 10 degrees, if possible.

- It is always best to have a few more pump strokes and a little more Reboiler temperature as an added benefit.

- After you have confirmed the outlet gas stream is dry, it is easy to lower Pump strokes and Reboiler temperature, rather than having a high Dew Point problem.

- Initially try to achieve a two (2) pound Dew Point rather than a seven (7) pound Dew Point on startup. If you miss the two (2) pound and get a seven (7) pound Dew Point, everything is already operating normally.

- DEWPOINT OPTIMUMIZING (SETTING)

- Do not operate the glycol system beyond requirements necessary to dry the natural gas stream below contract specifications. The gas purchaser will not pay more for gas that is dryer than the contract specifications. This optimization of the dewpoint saves on fuel gas costs, pump wear, BTEX loading, glycol degradation, and reboiler fire-tube wear (just a few of the benefits).

- A note to remember concerning Dehydration Systems: "A OUNCE OF PREVENTION IS WORTH POUNDS OF WATER''
  By Dronald Dore' (Document's Original Author)

DAILY (ROUTINE) INSPECTION REQUIREMENTS

THESE INSPECTIONS SHOULD NOT TAKE MORE THAN 10 TO 30 MINUTES IF THE SYSTEM IS OPERATING PROPERLY. ADD THE FINDINGS AND WORK DONE TO THE RECORD BOOK OR TO A COMPUTER FILE FOR THE GLYCOL UNIT.

- DAILY INSPECTIONS:

1. Reboiler temperature
2. Pump strokes
3. Reboiler surge level
4. Gas-Glycol-Condensate Separator levels and pressure
5. Filter or Filtration System – Differential Pressure Indication (DPI)
6. Filter changes

7. Reflux Still Column temperature
8. Burner system
9. Fire-tube for hot spots
10. Glycol Contact Tower controls
11. Natural Gas Stream flow rates
12. Contact Tower gas stream temperature and pressure
13. Glycol leaks
14. Outlet Gas Stream Dew Point

- ADDITIONAL DAILY OR WEEKLY INSPECTIONS:

1. Take glycol samples (for lab test on a monthly or quarterly basis) per company policy.
2. BTEX Unit daily checks.
3. Other accessories such as the safety system.
4. pH factor (check weekly).

- PREVENTIVE MAINTENANCE RECORD KEEPING

- One of the best methods for preventing the development operating problems is to have an effective maintenance program, not only for equipment, but also for the glycol and chemicals. The records will provide the facility operators with an accurate analysis of operating expenses of the glycol unit. Expenses that are excessive or too frequent can be easily identified.

- Solutions to problems are helped greatly by accurate information found in detailed facility records. Record keeping is a valuable tool for cost analysis and helping to find good solutions for trouble-shooting.

- Many clients maintain excellent record books, monitoring the essential components and actively pursue a good scheduled maintenance program. These facilities generally have a glycol system that is operating at peak efficiency, with very few problems and a lower than average operating cost.

- MAKING A SPREAD SHEET FOR GLYCOL SYSTEM

- A daily record book should have all of the items listed below and any outstanding notations required for future references. The information may be entered on a data base spread sheet for computer usage. Include all items to be monitored for a permanent record reference.

- The data/identification of each piece of permanent equipment/component with the equipment description.

- The rated operating capacity of the dehydration system at its pressure and temperature design parameters should be in included.

- Sock Filter or others (such as 5 micron Sock Filters) list the Stock Numbers and other data required for ordering, quantity, etc. for replacement.

- Charcoal Filter replacement elements. List the Stock Numbers and other data required for ordering, quantity, etc. for replacement.

- Amount of glycol added with date. Be realistic with the amount of glycol used. Denote large amounts lost.

- Pump change out date.

- Dew Points recorded with date.

- Reboiler temperature (daily).

- Pump circulation rate (daily).

- Contact Tower gas flow rates with temperature and pressure (daily)

- Gas-Glycol-Condensate Separator pressure and temperature (daily).

- Glycol test results with date taken (4-8 week intervals). Always analyze the results. Follow up on any changes needed to the glycol system.

- Chemicals added, date and amount. Denote any foaming problems. Be quick to follow up on this problem. A large glycol loss will occur, if this situation is not corrected quickly.

- Glycol pH test results and date (PH of 7 to 8.5 is best).

- Comment section for notes. Denote items/requirements.

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Glycol Dehydration

Unit IV

Glycol System Maintenance, Care & Trouble Shooting

A SCHEDULED PREVENTIVE MAINTENANCE PROGRAM WILL:

- Reduce Glycol Losses
  - — Foaming
  - — System — Plugging
- Reduce Mechanical Failure
  - — Corrosion
  - — Pump Failures
- Minimize System Downtime
- Maximize System Operation Effeciency

PREVENTIVE MAINTENANCE AND YOU

A glycol system preventative maintenance program requires the efforts of field and office personnel alike. In return the operating cost and down time of the glycol dehydrator can be minimized. There are five distinct areas of involvement when initiating a glycol system preventative maintenance program.

Record keeping is the first step in maintaining the units' peak performance. A record of prior and existing unit conditions including dew points, glycol usage, and repairs will help establish a "personality" for the dehydration unit. Once the "personality" is defined it becomes easier to notice unusual system traits which may indicate potential problems.

Next, day to day physical inspections by the operator are necessary to keep the unit running smoothly. Any trouble encountered should be dealt with immediately to prevent escalation of the problem.

Regular chemical analysis of the glycol provides detailed information of the internal operation of the unit. Some process problems can be diagnosed well in advance of mechanical failure. Chemical problems can be diagnosed and corrective action taken before they become costly and detrimental to unit performance.

All units should have some provisions for corrosion control. The nature of glycol dehydration systems is such that corrosion is a frequent problem. If allowed to exist unchecked the damage can be extensive.

Communication lines between the field and the office are critical to the smooth operation of any production system. Office personnel such as production supervisors, facility engineers and purchasing agents must be kept informed of the day to day operations and particularly any problems which may arise. Field personnel must be made aware of technical information which may improve their operations, including management decisions on major process changes being considered. Training for field operators is very important and must be addressed by management and supervisory positions. Understanding the dehydration system and how it works allows the operator to better maintain the equipment. Communication of information translates into greater efficiency.

WHAT RECORDS TO KEEP?

To define the "personality" of any glycol unit the following records are necessary:

1. Design information including vessel specifications, drawings and flow sheets.
2. Filter element or media replacement. Type and frequency.
3. Glycol usage. Gallons/month.
4. Chemical additives. Type and amount.
5. Gas production and flow rate charts. Peak, average, low periods.
6. Sales or lift gas dewpoint/water content. Pounds/MMSCF.

7. Mechanical inspections. Type, magnitude, frequency, results.
8. Glycol analysis. Format, frequency, recommendations, results.
9. Corrosion coupon results. MPY, frequency.
10. Receivers on materials and labor relating to system repairs. Operating costs.

With this information a good portrait can be drawn of any individual system. Updating these records regularly will show any gradual changes to your unit's "personality" and may alert you to potential or developing problems.

MECHANICAL MAINTENANCE

To keep the glycol unit operating properly and to prevent operational problems there are a few things the operator needs to do on a regular basis.

1. The glycol unit's controls and instruments are very important. Most of the time the glycol unit operates semi-attended. The controls and instruments must be in good working shape if the unit is expected to run by itself. Are these controls operating smoothly and responding to changes in operating conditions? If not, have an instrument technician take a look. Controls that don't work properly can be the start of costly and time consuming problems. Replace bad thermometers and pressure gauges. Trying to operate a glycol unit with bad thermometers and gauges is like watching television with no sound - its difficult to understand what's going on. Use a test thermometer on the reboiler to insure proper reboiler heat.
2. The preventive maintenance program should schedule a change of glycol filter elements based on an average expected need basis. Usually sock filters should be changed every 30 days. Carbon filters may range form a 30 day change out on small cartridge type filters to 180 day or longer on large bulk type units. Glycol analysis will help determine the necessary frequency. An upset or sudden change in operating conditions may foul the filters faster than the preventive maintenance program anticipated. Make sure the sock filter differential pressure is below 15 pounds. If not, change the elements; otherwise, a filter case internal relief valve may open which bypasses the filter elements, eliminating filter protection.
3. Look for glycol leaks on and around the glycol skid. A drop at a time soon adds up to a mess. Many of these leaks can be stopped by just taking a little time to tighten a union, valve stem packing or pump rod packing. On most units the pump rod packing is supposed to leak a little bit. This is necessary for lubrication of the rod, so don't tighten it too much. After the leak has been repaired clean the affected area.Not only does a clean glycol skid make it easier to notice new leaks, but clean equipment and piping is safer to work around.

4. Check the level of glycol in the storage tank once or twice a shift and add glycol when needed. Keep a written record of glycol added to the storage tank. This way you can see excessive loss of glycol and can start looking for the trouble a lot quicker.
5. Take a dew point once a day if possible to insure unit performance. Clean the glycol strainers every 30 days to prevent accumulation of trash which may cause glycol pump failure. The glycol circulation rate should be checked daily. Any time the gas flowrate changes or when ever a drastic change in gas pressure or temperature is experienced, recalculate the glycol flow rate and set pumps accordingly. For units with two or more glycol pumps, once a week switch pumps. This will insure pump operation when necessary.
6. If the reboiler is the direct fired type, once a week sight down the firetube for firetube blisters or tube hot spots. These indicate extreme system fouling and impending firetube failure. Cycle the main burner manually to be sure the fuel gas valve works and the pilot light stays lit. Check the fuel gas scrubber pot for fluid build-up that may hinder burner operation.

GLYCOL CARE

Glycol care is very important. The glycol unit may be operating within designed parameters and still achieving a high dewpoint or unexplained glycol loss. Some contaminated glycol problems can be noticed easily and corrective action taken. Each day take a small glycol sample from the surge tank or dry glycol suction header to the pump. Check it closely for the fine black particles settling out of the sample. This may be corrosion by-products and indicate an internal corrosion problem. Smell the sample. If the smell is sweet and aromatic - similar to rotten bananas - it may be thermally decomposed. If the glycol sample is viscous and black it is probably contaminated with hydrocarbon or well treating chemicals. Occasionally the hydrocarbon contamination may be great enough that the sample will separate into two liquids or "interphase".

Every four to eight weeks send a sample of the lean and rich glycol to a laboratory for complete analysis. The glycol analysis should include tests to determine values for pH, water content, hydrocarbon content, chlorides, iron, suspended solids, residue, foam tendencies in both height of foam and stability in seconds to break, specific gravity and glycol composition. This type of analysis when interpreted by the operator, production supervisor or unit engineer will provide a detailed description of unit performance and glycol condition (see Appendix "J").

CORROSION CONTROL

Corrosion is a major cause of premature equipment failure. It is usually attributed to oxygen in the system. Basically, oxidation of metal is the exchange of electrons between metal and oxygen molecules to form positive and negative hydrogen ions. Some metal loss is incurred. The resultant scale like residue formed by the process is called oxide. More commonly it is called rust. Oxidation is characterized by rough, irregular, shallow pitting of the metal scaled over with rust.

In addition to oxygen, acidic environments also lend themselves to corrosion. Acid gases such as hydrogen sulfide and carbon dioxide are often found in produced natural gas. These compounds will also exchange electrons with metal molecules initiating corrosion.

Glycols are very reactive with sulfur compounds, such as hydrogen sulfide (H_2S). The resulting materials tend to polymerize, that is, to form a large molecule make from a repeating succession of smaller molecules. In glycol systems this polymerization will form a "gunk" which is very corrosive. Corrosion associated with H_2S is called "sour" corrosion. Sour corrosion is characterized by deep, jagged pitting.

Water can be found in glycol units as vapor, free condensed water, or entrained in glycol. Carbon dioxide when dissolved in water forms carbonic acid. Because almost all natural gas contains some degree of carbon dioxide, the presence of carbonic acid in glycol systems is very common. The corrosion resulting from carbonic acid is known as "sweet" corrosion. Sweet corrosion is characterized by deep, round, smooth pitting. Sometimes the pitting will cover a broad area disguising the depth of the pit.

These three types of corrosion, OXIDATION, SOUR CORROSION and SWEET CORROSION are almost always present in glycol systems either individually or in combination with one another.

Corrosion can occur over the entirety of the glycol system, inside and out. The two most common areas of severe corrosion related damage are the still column reflux coil and the vent/fill connection on the surge tank. This is due to a high concentration of water vapor in the top of the still and the ready availability of oxygen in the air at the vent/fill cap.

Corrosion prevention and control programs should include system monitoring through the use of corrosion coupons and close monitoring of glycol analysis values for PH and iron. The major steps used in combating corrosion in glycol systems are:

1. Use of an effective corrosion inhibitor in both the liquid and vapor phases of the unit.
2. Use of non-corrosive metals in construction.
3. Keep the unit clean. Prevent acid formation due to contamination.

Cathodic protection has been attempted but met with little success.

It is impractical to attempt to eliminate corrosion completely. However, the rate of corrosion can be slowed to a point that is almost negligible. Corrosion rate is measured in metal loss for a given time period. It is commonly described as "mils per year" or MPY. Six MPY is about the highest acceptable rate of corrosion.

Proper use of corrosion inhibitors can effectively control corrosion. Corrosion inhibitors work in several ways. The two most applicable to glycol units are "plating" inhibitors and "pH buffers". pH, as described elsewhere in this text, is the measure of acidity or alkalinity of a substance. The alkanolamines, MEA and TEA, are pH buffers. They fight corrosion by stabilizing the glycol pH near neutral, thereby reducing corrosive environment. Amines are not true inhibitors in that no protection is actually afforded the metal surface. The alkanolamines are regenerable as is the glycol and therefore can be retained in the system for lengthy time periods. They are however, thermally degraded at the normal operating temperature of a glycol reboiler and if used frequently may leave harmful residues within the system.

Unlike the alkanolimines which are inorganic amines, tallow diamine is an organic amine. It is grouped with the "plating" inhibitors even though it does not actually plate out on the vessel walls. As the alkanolamines, tallow diamine flashes out of the glycol at high temperatures. As it vaporizes it contacts the vapor spaces of the reconcentrator and forms a tenacious film over the exposed metal. This film will eventually wear away and must be replenished occasionally to continue protection. Tallow diamine, to a slightly lesser degree than the alkanolamines, will also buffer pH.

The true "plating" inhibitors are borax, NaCap (sodium mercaptobenzothiazole), and dipotassium phosphate. These inhibitors are strictly liquid phase protection. They will plate out on the vessel walls forming a protective barrier between a corrosive environment and the metal. This barrier also prevents the ready exchange of electrons which drastically slows corrosion. Since the plating inhibitors are all alkalies, some degree of pH buffering will be effected. The pH buffering will not be as great as through the use of the amines.

COMMUNICATION

Probably the easiest portion of an effective maintenance program and yet the most over-looked is communication. Communication between operators on opposite shifts, communication between office and field personnel, communication between management and labor, communication between engineer and foreman. If any single factor contributes to glycol system failure it is probably lack of communication. Consider trying to operate a dehydration system without knowing if the glycol filters have been changed or how much glycol losses are being experienced. Imagine trying to accurately troubleshoot a glycol

system without knowing the immediate history of the problem or without knowing the results of a glycol sample analysis. Failure to communicate can cause confusion and evolve into major problems. Know to whom information on the glycol system must be passed and make a conscious effort to communicate.

WHEN IS THERE A PROBLEM?

Even the best preventative maintenance program will not guarantee the dehydration unit will operate trouble free. The one most obvious indication of a glycol dehydrator malfunction is high water content (dew point) of the outgoing gas stream. In the majority of cases, this is brought about by insufficient glycol circulation or by insufficient reconcentration of the glycol. These two problems can be caused by a variety of contributing factors. In addition to mechanical causes, high dew points may be found due to existing operating conditions for which the equipment was not designed. These conditions can sometimes be at least partially alleviated by both changes in condition and mechanical operation.

HIGH DEW POINTS

I. Cause - INSUFFICIENT GLYCOL CIRCULATION

A. Electric driven piston pump.

1. Check flow rate indicator (if present) to insure proper glycol circulation. If no flow rate indicator is present verify circulation rate by closing glycol discharge valve from contactor and timing fill rate in gauge column (see Appendix "K").
2. Check high pressure dry glycol by-pass valve. Close if necessary.
3. Check pump prime by shutting pump down, closing the discharge valve, opening the by-pass valve and re-starting pump. Allow to run briefly under no load through the by-pass line to remove any trapped gas in the pump.

B Glycol-gas powered pumps (Kimray).

1. Close dry discharge valve. If pump continues to run, open dry discharge bleed valve and allow to run a few strokes. Once all gas is purged from pump close the bleed valve. If pump continues to run, discontinue use and send in for repair.
2. If pump will not prime, but continues to run gas through the dry discharge bleed valve then:
   a. check pump suction strainer for plugging.
   b. check glycol level in surge tank.

C. Check heat exchangers and glycol piping for restrictions or plugging.

II. Cause - INSUFFICIENT RECONCENTRATION

A. Verify reboiler temperature with test thermometer. (350 degrees to 400 degrees Fahrenheit) Raise temperature if necessary.

B. Check glycol to glycol heat exchanger for leakage of wet glycol into the dry glycol stream.

C. Check stripping gas if applicable. Be sure stripping gas is in service at the proper rate.

D. Check for communication between the reboiler vapor space and the surge tank vapor space. Communication could mean contaminated dry glycol going to the pump.

III. Cause - OPERATING CONDITIONS DIFFERENT FROM DESIGN

A. Check operation of upstream separators and scrubbers. Be sure not to overload system.

B. Increase absorber pressure. This may require installation of a back-pressure valve.

C. Reduce gas temperature if possible.

D. Increase circulation rate if possible.

E. Increase reboiler temperature if possible.

IV. Cause - LOW FLOW RATE

A. Blank off a portion of the bubble caps if possible.

B. Lower system pressure.

C. Add additional cooling to dry glycol and increase circulation rate.

D. Change out absorber to a smaller unit designed for a lower flow rate.

V. Cause - INTERNAL ABSORBER TRAY DAMAGE

A. Open inspection ports and/or manway and verify tray integrity. Repair or replace as necessary.

VI. Cause - BREAK—DOWN OR CONTAMINATION OF GLYCOL

A. Have lean and rich glycol sample analyzed. Note evidence of severe contamination, thermal decomposition, or chemical decomposition. (see Appendix "J"). Clean system and/or recharge with fresh glycol as necessary.

GLYCOL LOSS - FROM THE CONTACTOR

I. Cause - FOAMING

A. Major cause of foaming is contamination. (see Appendix "J"). Remove source of contamination. Clean contactor if necessary, clean system if necessary, replace glycol if necessary.

B. Increase filter capacity and/or add carbon filtration.

C. Add anti-foam compound (silicon emulsion type).

D. Adjust high pH to prevent emulsification (use acetic acid).

II. Cause - PLUGGED OR DIRTY TRAYS

A. Clean trays.

1. Manually enter tower and clean.
2. Open inspection ports and clean with water jet or by hand.
3. Chemically clean.

III. Cause - EXCESSIVE VELOCITY

A. Decrease gas rate.

B. Increase absorber pressure.

IV. Cause - INTERRUPTED LIQUID SEAL ON THE TRAYS (gas surge)

A. If the contactor has a by-pass valve, isolate the tower by opening the by-pass valve and closing the gas inlet valve. Allow the glycol pump to run 5 minutes then while the glycol is circulating open the gas inlet valve and slowly close the gas by-pass valve.

B. If contactor has no gas by-pass:

1. Stop or greatly reduce the gas flow through the tower (shut wells, flare gas, alternate system, etc.). Allow the glycol to circulate 5 minutes then slowly turn the gas back through the tower.
2. If unable to stop or reduce the gas flow, increase the glycol circulation rate to the maximum possible for 2 - 5 minutes (flood trays in attempt to re-establish seal using liquid head pressure).

V. Cause - COLD GLYCOL (cold gas)

A. Increase gas temperautre by increasing temperature of flow line heater or add flow line heater if necessary.

VI. Cause - LEAKS

A. Pressure test external gas-glycol heat exchanger for glycol leakage into dry gas stream.

B. Check drain header (if applicable) at all gauge columns, external float cages (LSHL), etc.

VII. Cause - ACCUMULATION IN INTEGRAL SCRUBBER

A. Check for communication between chimney tray and scrubber section.

B. Check bottom tray leakage. May have damaged or improperly constructed chimney.

C. Check glycol level control and dump valve operation. (on units with electric powered glycol pumps).

GLYCOL LOSS - FROM THE REBOILER

I. Cause - EXITING STILL COLUMN
   A. Plugged or fouled still column packing. Clean or replace still column packing.
   B. Saturated glycol (droplets blowing out still)
      1. Check reboiler heat source. Insure heat is between 350 degrees to 400 degrees Fahrenheit.
      2. Check for free liquid or misting liquid carry-over into contact tower. Repair or replace separator control if necessary. Reduce slugging if possible. Add scrubber if necessary.
      3. Reduce glycol flow through reflux coil. Raise reflux temperature.
   C. Vaporization
      1. Check reboiler temperature (below 404 degrees Fahrenheit).
      2. Check reflux temperature - increase glycol flow through reflux coils to lower reflux temperature.
      3. Check stripping gas flow rate.
   D. Plugged or fouled glycol outlet from reboiler (downcommer or heat exchangers).

II. Cause - LEAKS
   A. Be sure all drain valves are closed.
   B. Be sure gauge column seals are good.
   C. Check heat tube integrity (glycol loss into fire tube or waste heat tube will produce heavy smoke from stack).
   D. Check reboiler shell integrity. (note glycol leakage from insulation, wet insulation, or tell-tale stains.
   E. Heat source flange leak (poor gasketing).

III. Cause - BAD GLYCOL RELIEF VALVE
   A. Replace glycol relief valve.

GLYCOL LOSS - GLYCOL HYDROCARBON SEPARATOR

I. Cause - IMPROPER CONTROL OPERATION
   A. Repair or replace level control.
   B. Clean, repair or replace dump valve.

II. Cause - LEAKS
   A. Check drain valve. Tighten, repair or replace.
   B. Check gauge columns, external float cages, and level control adapters.
   C. Add anti-foam compound to prevent loss through gas outlet.

III. Cause - ACCUMULATION IN OIL BUCKET

A. Open vessel and clean glycol passage under oil bucket (horizontal vessels).

B. Adjust or remove weir.

GLYCOL LOSS - MISCELLANEOUS

I. Cause - LEAKS

A. Check all flanges, unions, and associated piping.

B. Check electric pump rod packing.

C. Check all drain valves (filter, heat exchanger, etc.).

D. Check pump bleed valves (and electric pump by-pass).

E. Check external gas-glycol heat exchanger.

II. Cause - POOR QUALITY OR CONTAMINATED REPLACEMENT GLYCOL

A. Use only virgin triethylene glycol with 97% or better purity.

B. Check glycol content for excessive water.

Glycol Dehydration

Unit V

Glossary Of Terms & Appendixes

Glycol Dehydration Terms & Definitions

Absorption: The process or ability of a **liquid desiccant** such as triethylene glycol to absorb (remove and retain) water vapor from natural gas.

Adsorption: The process or ability of a desiccant such as silica gels or molecular sieves (**solid desiccants**) to absorb (remove and retain) water vapor from natural gas.

BTEX: Hazardous chemicals (**B**enzene, **T**oluene, **E**thylbenzene and **X**ylene) emitted from the Glycol Reboiler's Still Column during the distillation process. These harmful or volatile organic compounds are the byproducts of the glycol regeneration process.

Blanket Gas: Very low pressure natural gas introduced into a storage tank to prevent oxygen and/or steam from contaminating (oxidizing) glycol or other contents contained within.

Bubble Caps: Metal components that have special elongated openings ("slots") to redirect the natural gas stream (internal flow) downward to produce multiple small gas bubbles within a triethylene glycol liquid layer. The natural gas bubbles come into intimate contact with the triethylene glycol liquid.

Carry-over (Liquid Overflow): The undesirable event of discharge of liquids through a natural gas or vapor outlet.

Condensate (Hydrocarbon Liquid): Clear liquid phase of hydrocarbon fluid generally associated with natural gas production. The presence of condensate is very undesirable in the glycol dehydration distillation system. It can be absorbed along with water by glycol fluid and should be properly separated and removed in the Gas-Condensate-Glycol Separator or Skimmer.

Contactor (Glycol Contact Tower or Absorber): A vertical pressure vessel within which the natural gas stream and glycol come into contact for the water absorption process to take place. Typical large unit contact towers have one of the following internal components: Bubble Caps, Nutter trays, stacked Matrix tray components.

Small contact towers or absorber units can have packed towers filled with Ceramic Saddles or Pall Rings (generally Stainless Steel material) to provide a porous internal flow path.

Dehydration: Refers to the process of removing water vapor content from a natural gas stream. There are three principal methods or processes of natural gas dehydration that are commonly utilized. The most prominent methods of water vapor removal are listed in order of usage: Glycol (Liquid Desiccant), Solid Desiccant (Beads, Tables, Pellets, etc., material in granular or chuck form) and Low Temperature Extraction (also known as LTX units).

Desiccant: A material that has a natural ability (affinity) to absorb and retain water vapor. The most commonly used Liquid Desiccants are the glycol fluids. Solid Desiccants are available in granular (Beads, Tables, Pellets) or chuck material forms.

Dew Point (Water Vapor Content Reference): The amount of water vapor contained within a natural gas stream at a particular temperature and pressure. It is also described as the temperature at which a natural gas stream is fully saturated with water vapor. This simply means that the natural gas stream is unable to retain any more water vapor, unless a change in temperature or pressure occurs. As the temperature is reduced, some of the water vapor will condense and become liquid. This is a phase change from a gas vapor state to liquid.

Dew Point Depression: The water content to be removed or dehydrated before shipment for sales. This quantity is generally all water except seven (7) pounds per million cubic feet (current industry standard). Dew Point Depression is often described as the difference between the water saturated natural gas stream and the contract dew point water content. The greater the difference between the saturated gas stream water content and the contract dew point, the greater the "Dew Point Depression" required.

Distillation (Glycol): The separation process that removes the water vapor content from Triethylene Glycol by heating the glycol/water solution fluid contents above the boiling point of water. The distillation process begins in the Still Column assembly as the incoming fluid solution is heated above 212° F to vaporize the water in solution with glycol.

Through the distillation process, the glycol fluid is repeatedly purified for continuous circulation and reuse within the system.

Free Water: Liquid water that is already separated from the natural gas stream or oil. Free water is normally removed prior to its entrance into the Glycol Dehydration system.

Gas - Dry: Natural Gas that has been processed (dried) to remove its water vapor content within client sales contract specification or predetermined requirements.

Gas - Wet: Natural Gas that has not been processed to remove its water vapor content.

Gas – Saturated: A natural gas stream that contains the maximum amount of water vapor at its current flowing temperature and pressure. It also means that the natural gas stream is unable to retain any more water vapor at its present condition. Natural gas normally flows from the wellhead assembly, fully saturated with water.

Glycol: Generally refers to Triethylene Glycol, which is a hydroscopic desiccant primarily used to remove water vapor from a flowing natural gas stream. The Glycol Circulation and Water Absorption method of dehydration is the most prominent means utilized since Triethylene Glycol has a natural affinity for absorbing water vapor.

Dry (Lean): The processed glycol fluid that has completed circulation through the Reboiler (Regeneration or Reconcentrator) distillation system, to remove its water vapor content. **The water content (mixed in solution with the glycol fluid) for dry or lean glycol should be less than 1%.** Dry or lean glycol also refers to water free glycol that is to be circulated concurrent to the flow path of the natural gas stream.

Wet (Rich): Refers to the glycol that has completed the absorption circulation process by flowing through the flowing natural gas stream and has absorbed the water vapor contained within. The water solution content in wet or rich glycol should not exceed more than 5 or 6%.

Heat Exchanger: Special assemblies that have internal flow cores within which, media (fluids or gases) is subjected to opposing flow to provide additional heating or cooling (according to specific process requirements). Heat Exchangers are used to increase the thermal operation efficiencies of glycol dehydration unit without additional sources of heat production or cooling systems. Heat Exchangers require thermometer installations at various strategic points to monitor temperatures for efficient operation of the system.

Heated Medium (Indirect Fired Unit): A fluid media that is heated and circulated through the Glycol Dehydration system by an indirect fired unit. An example is a Waste Heat Recovery system that provides heat for multiple assemblies. In these systems, the Reboiler has special internal piping coils instead of a standard firetube assembly.

Hydrates: Crystalline ice substance or frozen particles that forms primarily from the water vapor contained within a flowing natural gas stream as a decrease in temperature occurs. The formation of hydrates is dependent upon the pressure/temperature factors of the flowing natural gas stream.

Hydrocarbon: Generally refers to petroleum industry products that contain hydrogen and carbon atoms. The more carbon and hydrogen atoms combined within the hydrocarbon molecules, the greater the Specific Gravity or Vapor Density.

Liquid Seal: Glycol fluid level near the midsection of the Bubble Caps (above the elongated slots) that allows the stream of natural gas bubbles produced to come in intimate contact with the glycol. The glycol liquid level is controlled automatically by the weir's height.

MMSCF: Abbreviation for One Million(MM) Standard Cubic Feet of natural gas. One SCF is a Cubic Foot of natural gas at 60o F and at atmospheric pressure.

pH Factor: Measure of Acidity, Neutrality, Alkalinity (Base) of substances on a reference scale of 0 – 14. Strong acids start a "0" scale measurement, Neutral substances are a "7" measurement and the strongest Alkaline substances are a 14 on the pH measurement scale.

Packing: Ceramic Saddles, Pall rings and other special designed material that will provide a porous internal flow path upward through a process component such as a Glycol Contact Tower or a Reboiler's Still Column.

Reboiler (Reconcentrator): Heated process vessel within which the distillation (boiling off) process takes place to separate the water from the water/glycol liquid solution.

Reboiler Still Column: The Reboiler's vertical mounted process component within which the water/glycol liquid solution begins the distillation process.

Regenerative Process: The distillation of the water/glycol liquid solution to separate and purify the glycol. The regenerative process also includes separation of hydrocarbons and other impurities from the liquid glycol.

Reflux: Process term used to describe the conversion (cooling/condensing) of hot glycol vapors for a return to a liquified state. This control or process method also allows the water to remains in its vaporized state for proper exhausting from the distillation system. The water vapor will rise through the assembly to continue on its departing (exhausting) flow path.

Reflux Liquid: The cooler water/glycol liquid solution that is circulated through piping coils within the Reboiler's Still Column. The cooler liquid solution is used to condense the glycol vapors mixed with the exhausting water vapor. This process prevents the loss glycol during normal operations.

Static Pressure: The pressurized state within process equipment or piping although no flow is occurring.

Storage Tank (Surge): Process vessel or component assembly within which regenerated or dry glycol is stored. A pump suction line is connected to this tank. It is generally not insulated to permit cooling. Additionally, glycol is added here once initial operations have begun.

Stripping Gas: A low pressure/low volume stream of warm natural gas that is percolated (bubbled) through glycol fluid being regenerated to additionally remove the water vapor content. The use Stripping Gas can purify glycol to almost 100%.

Thermal Decomposition or Degradation: A harmful change that occurs due to operating at excessive (high) temperatures or overheating a liquid product to affect its original composition and reduce its performance.

Tray (Bubble Cap): Plate assembly that has Bubble Caps, Weirs and Downcomers (and manways in larger units) attached in glycol dehydration Contact Towers. The number of trays within the Contact Tower is dependent upon the process requirements. Most Contact Towers have from 4 to 8 trays installed within them.

Weir: A dam like structure that is used hold a liquid contents consistently within a predetermined or fixed level. Weirs are found in Contact Towers, Reboilers and numerous other process vessels.

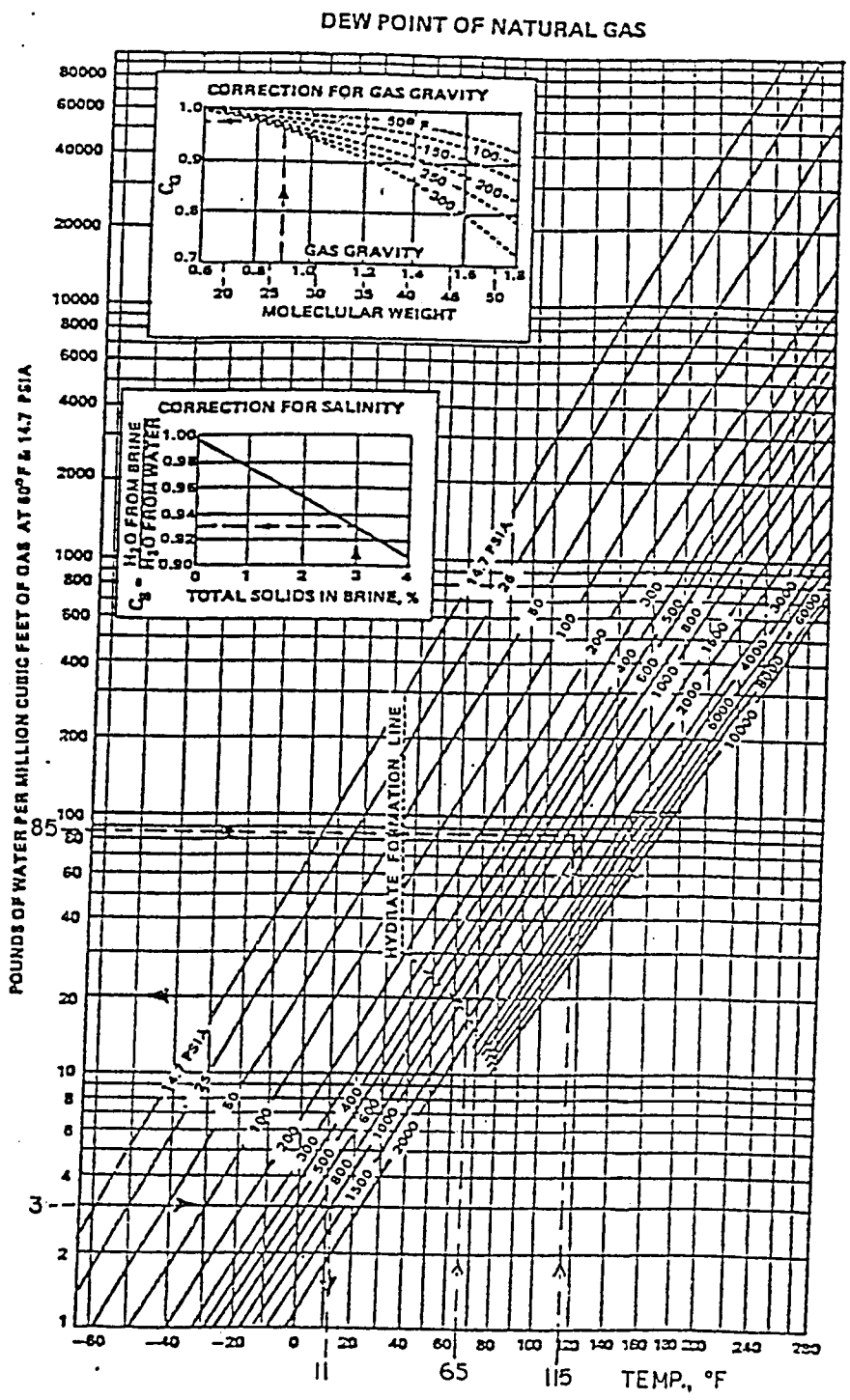

DEW POINT OF NATURAL GAS
CORRECTION FOR GAS GRAVITY
GAS GRAVITY
MOLECULAR WEIGHT
CORRECTION FOR SALINITY
TOTAL SOLIDS IN BRINE, %
POUNDS OF WATER PER MILLION CUBIC FEET OF GAS AT 60°F & 14.7 PSIA
HYDRATE FORMATION LINE
TEMP., °F
11
65
115

FIG. 1

TEMPERATURE DROP VS. PRESSURE DROP

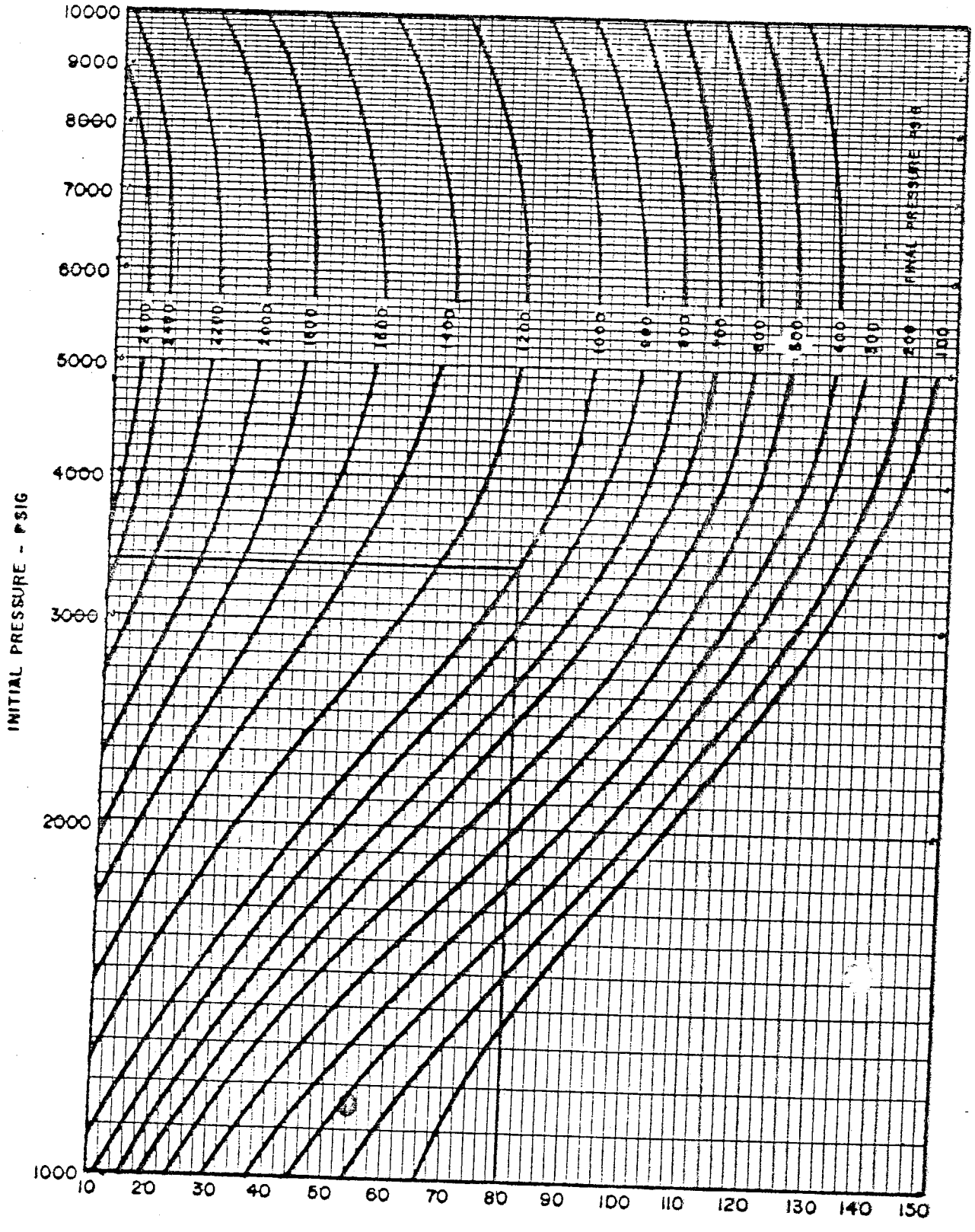


CHART 2

GLYCOL SELECTION

The glycols, ethylene, diethylene, and particularly triethylene are by far the most common desiccants used in liquid desiccant processes for the removal of water vapor from natural gas. They have gained widespread use in gas dehydration because:

1. They are highly hygroscopic, i.e., they readily absorb and retain water.
2. They are stable to heat and chemical decomposition at the temperature and pressures necessary in the process.
3. They have low vapor pressures, which minimize equilibrium loss of the glycol in the residual natural gas stream and in the regeneration system.
4. They are easily regenerated (water removed) for reuse.
5. They are noncorrosive and nonfoaming at normal conditions. Impurities in the gas stream can change this, but even then inhibitors can help to minimize these problems.
6. They are readily available at moderate cost.

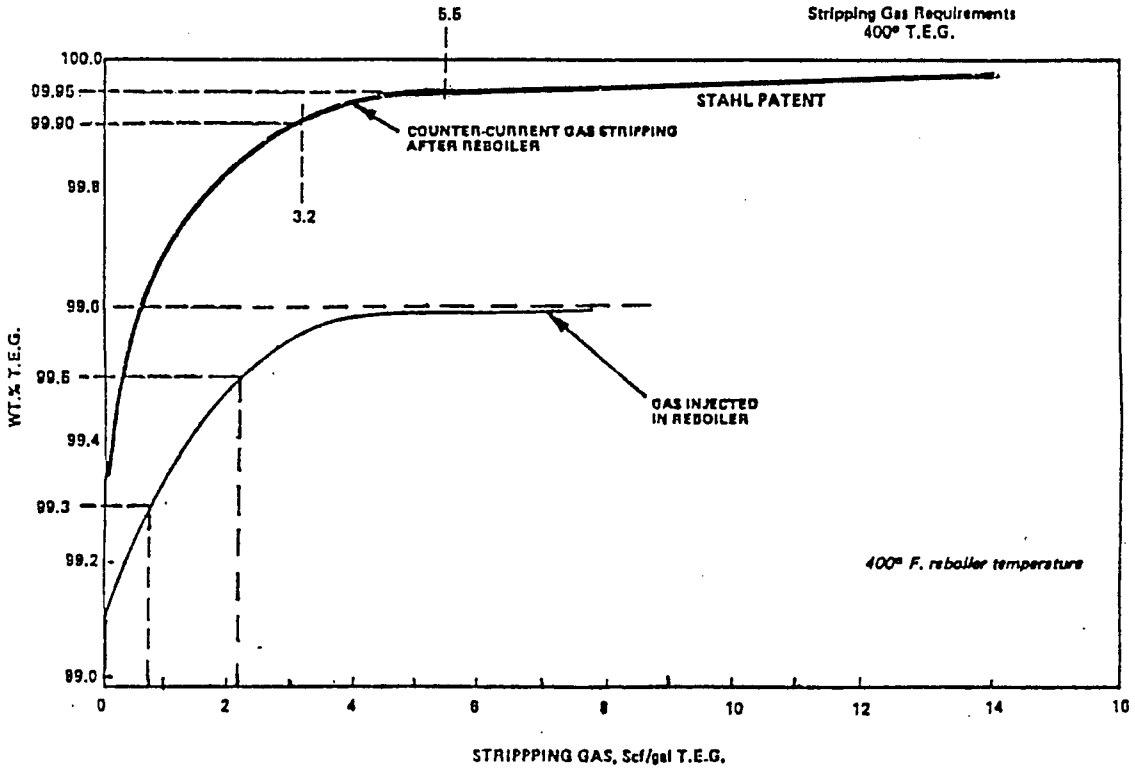
The hygroscopicity of glycols is affected by the concentration (glycol-to-water ratio); increasing as the concentration increases. Also, the dew point depression obtainable in a gas stream increases as the glycol concentration increases, and when the glycol concentration goes above 99.5%, the improvement can be dramatic. With a 100 degree inlet gas temperature, a depression of about 85 degrees Fahrenheit can be obtained with 99.0% TEG. This depression increased to 130 degrees Fahrenheit with 99.8% TEG and to 145 degrees Fahrenheit+ with 99.9% TEG.

To obtain 99.0% to 99.9%, TEG requires a reboiling temperature of 380 degrees to 400 degrees Fahrenheit. Since TEG does not begin to thermally degrade until 404 degrees Fahrenheit, it is possible to achieve the higher concentrations.

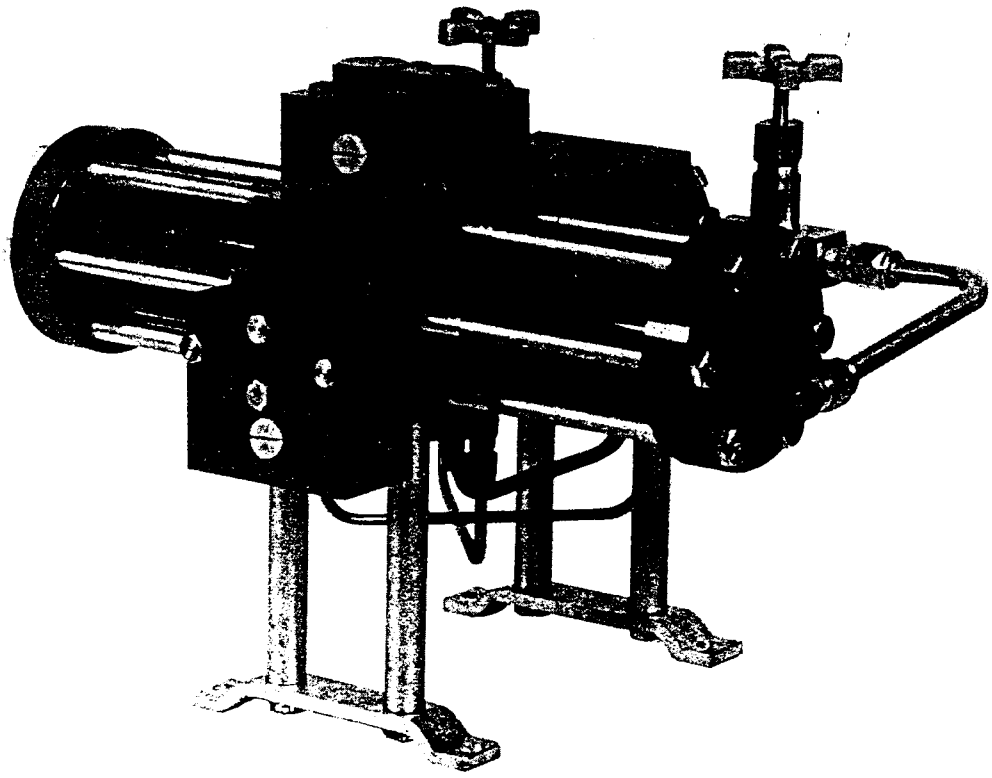
The same is not true of EG and DEG, which begin to degrade at 328 degrees Fahrenheit, resulting in a reboiling temperature of 325 degrees Fahrenheit and an upper concentration of 97.0%. With this concentration, the maximum attainable dew point depression would only be about 60 degrees Fahrenheit.

This is the main reason TEG is preferred in absorption systems over EG and DEG. In addition, it has a lower vapor pressure than EG or DEG, thereby decreasing the losses.

EFFECT OF STRIPPING GAS ON T.E.G. CONCENTRATION



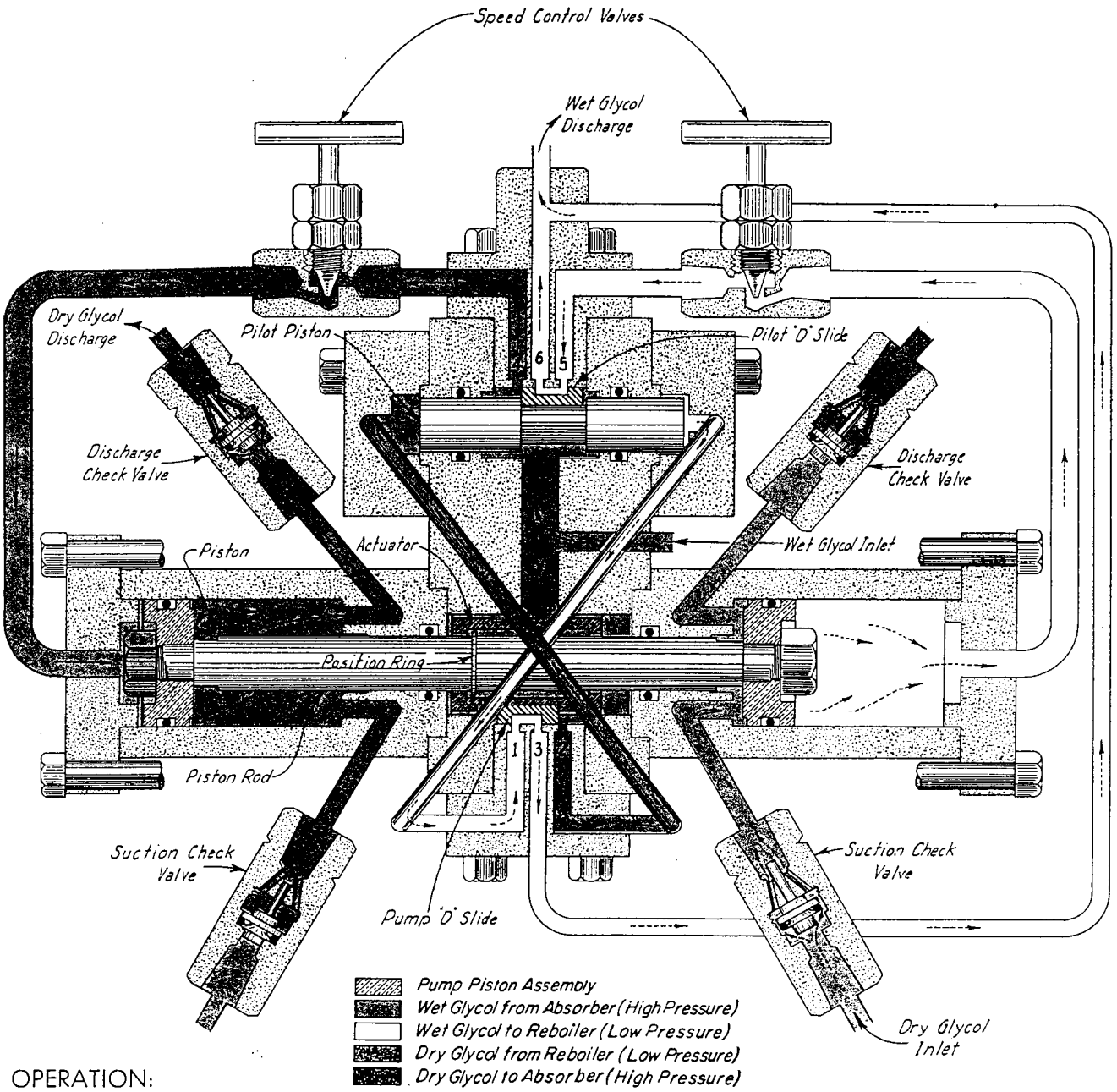
GLYCOL ENERGY EXCHANGE PUMPS



INTRODUCTION:

The Glycol Energy Exchange Pump, "Pressure Volume" or "PV-Series" Pump was developed in 1957. The initial consideration was a pump that would utilize the energy of the wet glycol at absorber pressure as a source of power. Within the confines of a system, energy can neither be created nor destroyed. Energy can, however, be stored, transferred, or changed from one form to another. The PV Series Pump transfers the energy available from the wet glycol, at absorber pressure, to an "equivalent" volume of dry glycol at reboiler pressure. In order to circulate the glycol, additional energy is needed to overcome friction losses within the pump and connecting piping. This additional energy is supplied by gas at absorber pressure.

The pump was designed as double acting with a maximum working pressure of 1500 psig with a factor of safety of ten. Corrosion and wear dictated use of the best materials available. These materials include stainless steel, hard chrome plating, nylon, Teflon, stellite, and "O"-rings specially compounded for glycol service. The pump contains two basic moving parts, a Piston-Rod Assembly, and a Pilot Piston. Each actuates a three-way D-slide.



OPERATION:

The Kimray glycol pump is double acting, powered by Wet Glycol and a small quantity of gas at absorber pressure (Red). Yellow denotes Wet Glycol and gas at atmosphere or low pressure. Dry Glycol (Blue) is being pumped to the absorber. Green is Dry Glycol suction from the reboiler.

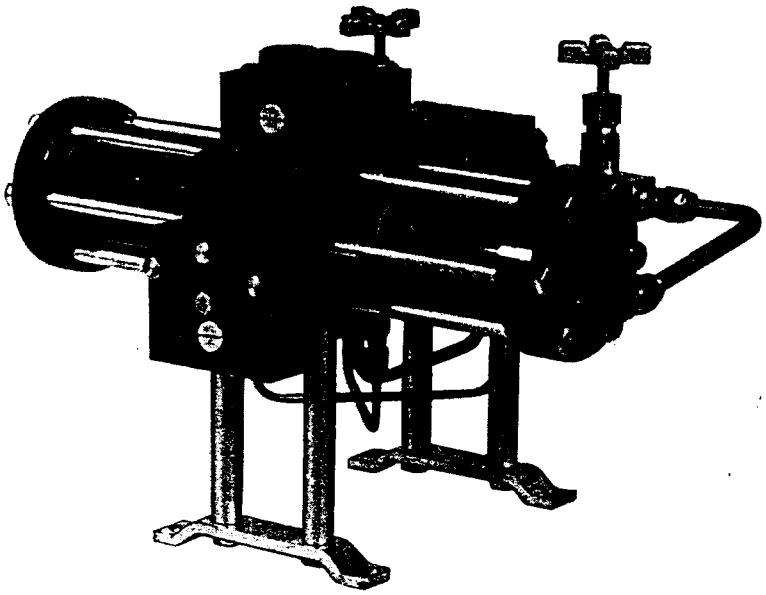
Wet Glycol (Red) from the absorber flows through port #4 and is throttled through the SPEED CONTROL VALVE to the left end of the Pump Piston Assembly, moving this assembly from left to right. Dry Glycol (Blue) is being pumped from the left cylinder to the absorber while the right cylinder is being filled with Dry Glycol (Green) from the reboiler. At the same time Wet Glycol (Yellow) is discharging from the right end of the Pump Piston Assembly to a low pressure or atmospheric system.

As the Pump Piston Assembly nears the end of its stroke, the POSITION RING on the PISTON ROD contacts the right end of the ACTUATOR. Further movement to the right moves the ACTUATOR and PUMP "D" SLIDE to uncover port #1 and communicate ports #2 and #3. This exhausts Wet Glycol (Red) from the left end of the PILOT PISTON through ports #2 and #3 to the low pressure Wet Glycol (Yellow) system. At the same time port #1 (which was communicated with port #3) admits Wet Glycol (Red) to the right end of the PILOT PISTON. This causes the PILOT PISTON and PILOT "D" SLIDE to be driven from right to left.

In its new position the PILOT "D" SLIDE uncovers port #5 and communicates ports #4 and #6. This exhausts Wet Glycol (Red) from the left end of the Pump Piston Assembly through ports #4 and #6 to the low pressure Wet Glycol (Yellow) system. Port #5 (which was communicated with port #6) now admits Wet Glycol (Red) through the right hand SPEED CONTROL VALVE to the right end of the Pump Piston Assembly.

The Pump Piston Assembly now starts the stroke from right to left. Follow above procedure reversing directions of flow.

KIMRAY, Inc. "PV" & "SC" SERIES GLYCOL PUMPS 1500 Lb. W.P. Oklahoma City, Okla.



PUMPS AVAILABLE:

Catalog Number	Model Number	Capacity Gal. / Hr. Min.	Capacity Gal. / Hr. Max.	Working Pressure Min.	Working Pressure Max.
AA	315 PV	3	13	100	1500
GAD	1715 PV	8	40	300	1500
GAB	4015 PV	12	40	300	1500
GAF	9015 PV	27	90	300	1500
GAH	21015 PV	66	210	300	1500
GAJ	45015 PV	166	450	300	1500

Catalog Number	Model Number	Capacity Gal. / Hr. Min.	Capacity Gal. / Hr. Max.	Working Pressure Min.	Working Pressure Max.
—	—	—	—	—	—
—	—	—	—	—	—
GAC	2015 SC*	8	20	100	500
GAG	5015 SC*	12	50	100	500
GAI	10015 SC*	22	100	100	500
GAK	20015 SC*	60	200	100	500

NOTE: To order a Pump with Viton O-Rings add -1 to Catalog number. Example: To order GAA with Viton O-Rings, specify: GAA-1.

MAXIMUM DESIGN PRESSURE FOR P.V. AND S.C. MODELS IS 1500 psig.

FEATURES:

Eliminates absorber liquid level controls.

No auxiliary power supply required.

Low gas consumption.

Completely sealed system prevents loss of glycol.

No springs or toggles — only two moving assemblies.

Hydraulic "cushioned" check valves with removable seats of hardened stainless steel.

APPLICATIONS:

Circulating pump for gas glycol dehydrators

Circulating pump for gas amine desulphurizers

CONSTRUCTION:

Materials for the vital working parts have been selected for greatest wear resistance. These materials include stainless steel, hard chrome plating, stellite, nylon and Teflon. Moving "O" Ring seals are compounded specifically for ethylene glycol service. A complete operational check is given each pump after assembly.

"O"-ring sealed check valve darts are standard in all except the model 315 PV. Teflon sealed darts are available. Capsule type ball checks are used in the 315 PV and are available for 1715 PV, 2015 SC and 4015 PV.

*These pumps are designed for operating pressures between 100 and 500 p.s.i.g. Maximum design pressure for all models is 1500 p.s.i.g.

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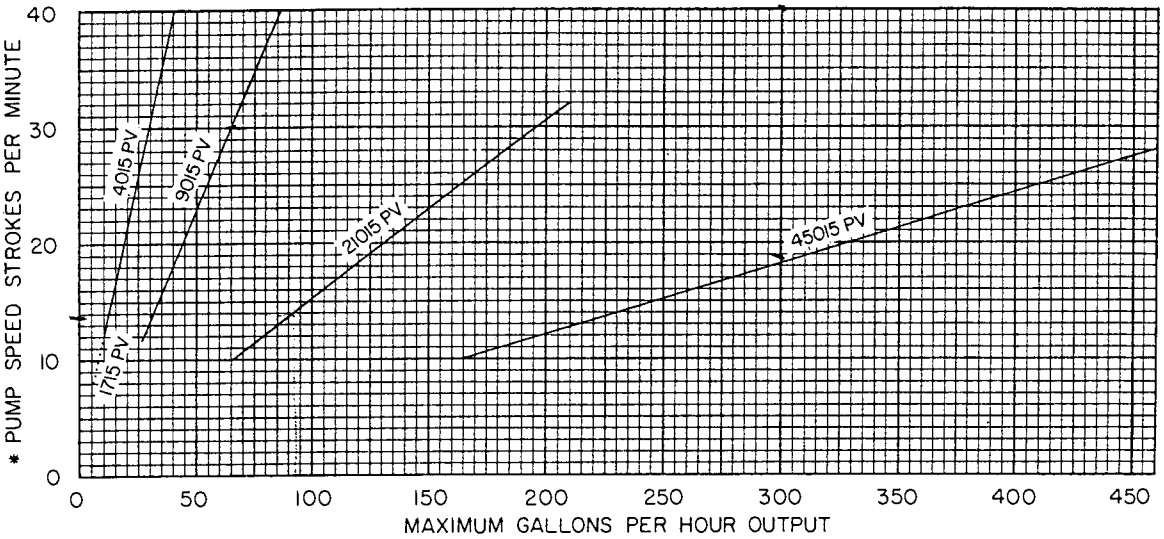
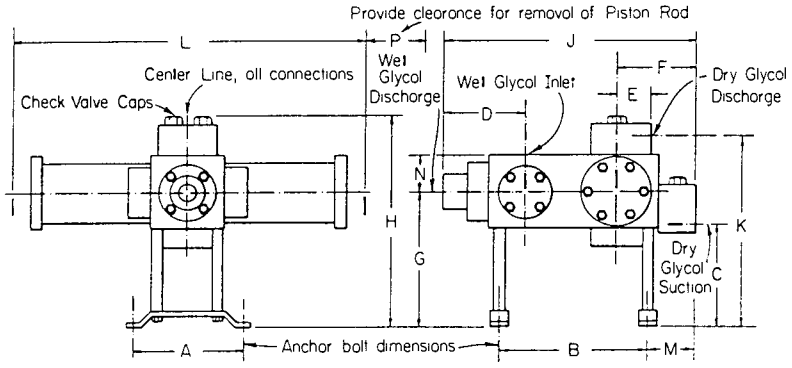
CIRCULATION RATE GRAPH



*It is not recommended to attempt to run pumps at speeds less or greater than those indicated in the above graph.

GAS CONSUMPTION

Operating Pressure—p.s.i.g.	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Cut. Ft./Gallon @ 14.4 & 60°F.	1.7	2.3	2.8	3.4	3.9	4.5	5.0	5.6	6.1	6.7	7.2	7.9	8.3



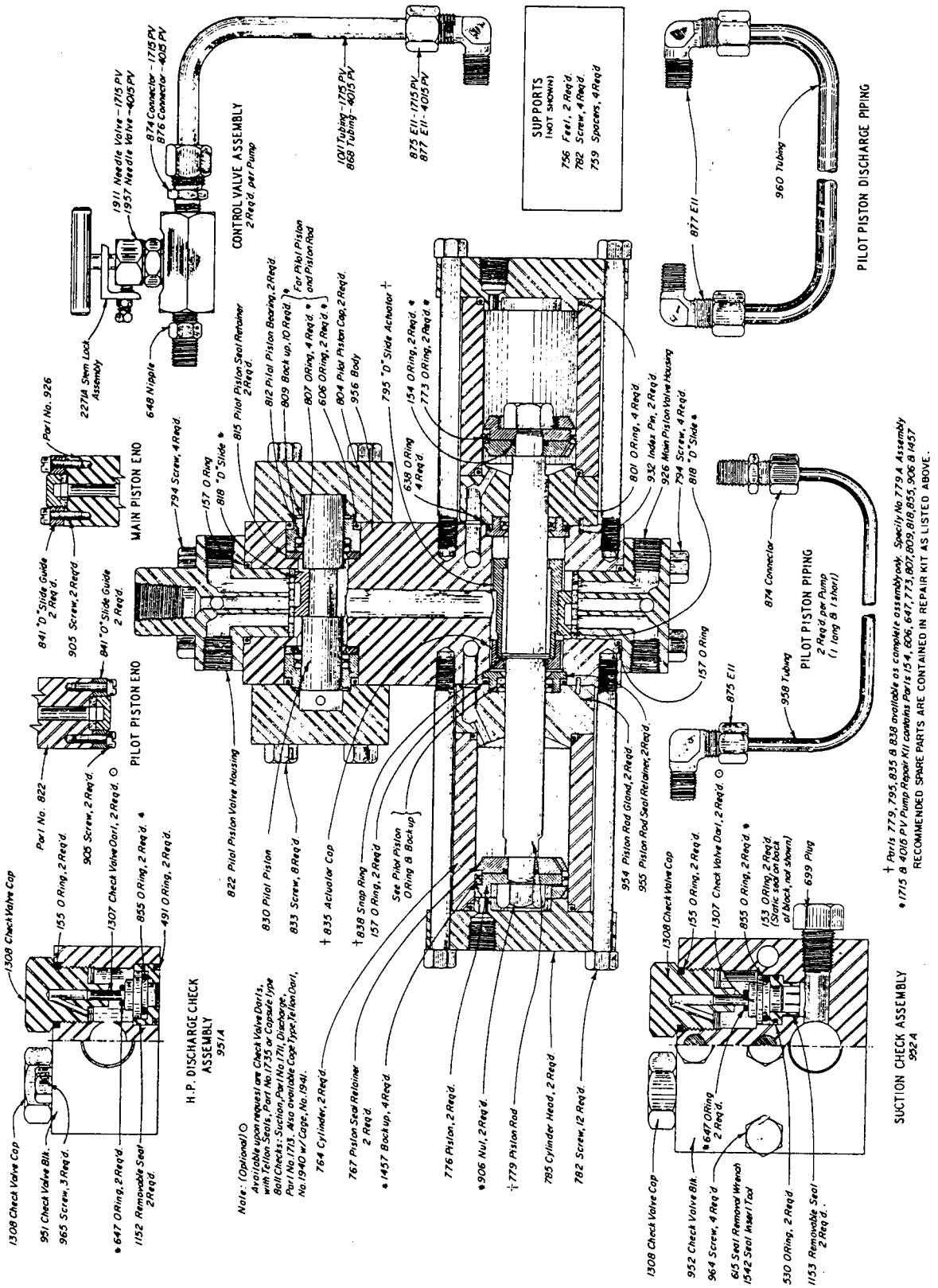
Model Number		Dimensions, Inches													
"PV" Series	"SC" Series	A	B	C	D	E	F	G	H	J	K	L	M	N	P
1715 PV		5¼	5 11/16	5¾	3 7/16	1½	3½	7¼	10⅞	10 3/16	9⅝	15	2⅛	1¾	3
4015 PV &	2015 SC	5¼	5 11/16	5¾	3 7/16	1½	3½	7¼	10⅞	10 3/16	9⅝	15	2⅛	1¾	3
9015 PV &	5015 SC	6¼	8¼ ± ⅛	6⅜	5	1¾	4¼	8¾	13¼	13⅞	11¾	20	2½	2	3
21015 PV &	10015 SC	7⅝	10⅛ ± ⅛	7	5⅜	2¼	5¾	9¼	14¾	16⅝	13	24	3 3/16	2½	4
45015 PV &	20015 SC	10¾	14 ± ⅛	9	6⅝	2⅝	6½	11⅜	19	21⅛	16⅜	34	3¾	3½	6

Model Number	Max. Cap. G.P.M.	Max. Cap. G.P.H.	Size of Pipe Connections	Mounting Bolts	Approx. Weight
1715 PV	.67	40	½" N.P.T.	⅜" Dia.	66 Lbs.
4015 PV	.67	40	½" N.P.T.	⅜" Dia.	66 Lbs.
9015 PV	1.5	90	¾" N.P.T.	½" Dia.	119 Lbs.
21015 PV	3.5	210	1" N.P.T.	½" Dia.	215 Lbs.
45015 PV	7.5	450	1½" N.P.T.	½" Dia.	500 Lbs.

DESIGN PRESSURE:
1500 Lbs.

MODEL 1715 PV & 4015 PV

WORKING PRESSURE:
300 Lbs. Minimum
1500 Lbs. Maximum


SUPPORTS (NOT SHOWN)
756 Feet, 2 Req'd.
782 Screw, 4 Req'd.
759 Spacers, 4 Req'd.
CONTROL VALVE ASSEMBLY 2 Req'd. per Pump
1911 Needle Valve - 1715 PV
1957 Needle Valve - 4015 PV
874 Connector - 1715 PV
876 Connector - 4015 PV
1011 Tubing - 1715 PV
868 Tubing - 4015 PV
875 E11 - 1715 PV
877 E11 - 4015 PV
877 E11
960 Tubing
PILOT PISTON DISCHARGE PIPING
2274 Stem Lock Assembly
648 Nipple
MAIN PISTON END
PILOT PISTON END
Part No. 926
Part No. 822
841 "O" Slide Guide 2 Req'd.
905 Screw, 2 Req'd.
794 Screw, 4 Req'd.
157 O Ring
818 "O" Slide •
815 Pilot Piston Seal Retainer 2 Req'd.
812 Pilot Piston Bearing, 2 Req'd.
809 Back up, 10 Req'd. } For Pilot Piston and Piston Rod
807 ORing, 4 Req'd. •
606 ORing, 2 Req'd. •
804 Pilot Piston Cap, 2 Req'd.
956 Body
795 "O" Side Actuator †
154 O Ring, 2 Req'd. •
773 O Ring, 2 Req'd. •
638 O Ring 4 Req'd.
801 O Ring, 4 Req'd.
932 Index Pin, 2 Req'd.
926 Main Piston Valve Housing
794 Screw, 4 Req'd.
818 "O" Slide •
874 Connector
PILOT PISTON PIPING 2 Req'd per Pump (1 long & 1 short)
958 Tubing
875 E11
157 O Ring
822 Pilot Piston Valve Housing
830 Pilot Piston
833 Screw, 8 Req'd
† 835 Actuator Cap
† 838 Snap Ring
157 O Ring, 2 Req'd
See Pilot Piston O Ring & Backup
764 Cylinder, 2 Req'd.
767 Piston Seal Retainer 2 Req'd.
• 1437 Backup, 4 Req'd.
776 Piston, 2 Req'd.
• 906 Nut, 2 Req'd.
† 779 Piston Rod
785 Cylinder Head, 2 Req'd
782 Screw, 12 Req'd
954 Piston Rod Gland, 2 Req'd
955 Piston Rod Seal Retainer, 2 Req'd.
H.P. DISCHARGE CHECK ASSEMBLY 951A
SUCTION CHECK ASSEMBLY 952A
1308 Check Valve Cap
155 O Ring, 2 Req'd.
1307 Check Valve Dart, 2 Req'd. ○
855 O Ring, 2 Req'd. •
491 O Ring, 2 Req'd.
961 Check Valve Blk.
965 Screw, 3 Req'd.
• 647 ORing, 2 Req'd.
1152 Removable Seat 2 Req'd.
699 Plug
153 ORing, 2 Req'd. (Static seal on back of block, not shown)
952 Check Valve Blk.
964 Screw, 4 Req'd
685 Seat Removal Wrench
1542 Seat Insert Tool
530 ORing, 2 Req'd
1153 Removable Seal 2 Req'd.
Note: (Optional) ○ Available upon request are Check Valve Darts, with Teflon Seats, Part No. 1735 or Capsule type Ball Checks: Suction, Part No. 1711, Discharge, Part No. 1713. Also available Cage Type Teflon Dart, No. 1940 w/ Cage, No. 1941.
† Parts 779, 795, 835 & 838 available as complete assembly only. Specify No. 779A Assembly
• 1715 & 4015 PV Pump Repair Kit contains Parts 154, 606, 647, 773, 807, 809, 818, 855, 906 & 1437
RECOMMENDED SPARE PARTS ARE CONTAINED IN REPAIR KIT AS LISTED ABOVE.

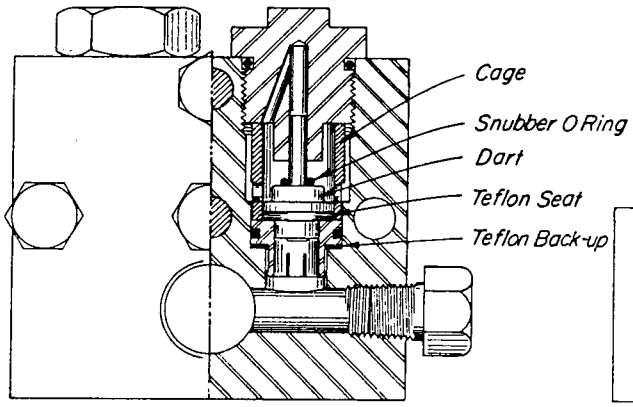
Cage and Teflon seat darts prevent spinning in Check Valve Blocks. Cage also acts as hold down for removable seat.

Snubber O Ring installed on stem portion of dart, decreases possibility of darts sticking in caps, snubs darts better, reduces spinning of dart and increases pump efficency.

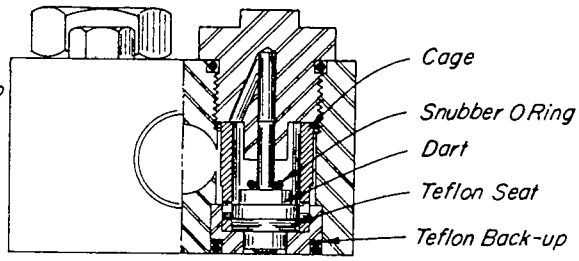
Installing Back-up to old Suction Blocks permits salvage, by locking the seat into the body and moves seat to non-worn portion of block.

Adding Back-up below seats in Discharge Block allows more squeeze to O Ring, preventing leaks.

PUMP SIZE	CAGE NO.	DART NO.	SUCTION BACK-UP	DISCHARGE BACK-UP	SNUBBER O-RING
1715 PV 2015 SC 4015 PV	1941	1940	1907	1666	647
5015 SC 9015 PV	1938	1937	1908	1667	647
10015 SC 21015 PV	1933	1932	1909	1668	153
20015 SC 45015 PV	1935	1934	2445	1669	265

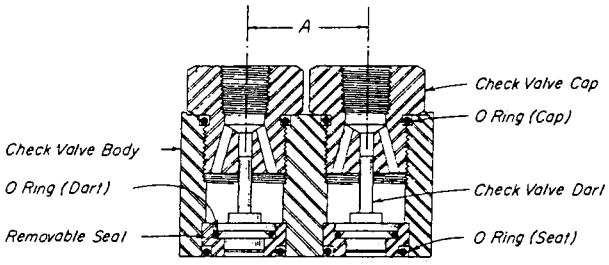


SUCTION CHECK ASSEMBLY



DISCHARGE CHECK ASSEMBLY

CHECK VALVE BLOCKS for SPLIT DISCHARGE



Kimray Glycol Pumps are available with check valve blocks for split discharge to serve two absorbers on a dehydration unit. On an original pump purchase there is no extra charge for this check block.

An accurately divided flow is assured since each absorber is served by one cylinder of the double acting pump.

For an installation of this type only one suction line is necessary. Also the high pressure wet glycol return may be manifolded through one filter or strainer to the pump.

When ordering any Kimroy pump for this service, specify the pump number and service. For example: 4015PV for "split discharge."

PART NAME	PART NUMBERS FOR INDICATED PUMPS					
	Quant. Req'd.	1715 PV	4015 PV and 2015 SC	9015 PV and 5015 SC	21015 PV and 10015 SC	45015 PV and 20015 SC
Check Valve Body	1	1194	1194	1195	1196	1197
"O"-Ring (Seat)	2	491	491	1151	156	801
Removable Seat	2	1152	1152	1131	1133	1173
"O"-Ring (Dart)	2	855	855	154	924	156
Dart	2	1307	1307	853	854	1163
"O"-Ring (Cap)	2	155	155	156	157	801
Check Valve Cap	2	1327	1327	1114	1199	1198
Tapped Hole Size	NPT	1 4	1 4	3 8	1 2	3 4
Dimension "A"	inches	11 16	11 16	27 32	1-1 32	1-1 2

EFFECT OF GLYCOL CONCENTRATION

The glycol circulation rate required for a given application is determined by a number of factors. Some of these are set by the inlet gas flow conditions and by the outlet gas dew point requirements; others are variable factors which are left for the designer's selection, and can have a considerable effect on the initial capital costs and ongoing operating costs of the equipment.

The non-variable factors include the inlet gas composition, flow rate, pressure and temperature, and the dew point requirements of the dehydrated gas. These factors obviously have a profound effect on the design of the equipment, and the owner should be as accurate as possible in establishing them. However, once these parameters are set, they become fixed in the equipment design.

Variable factors, for which the designer makes the selection and which affect the glycol circulation rate, are glycol concentration and the number of trays in the contactor.

If glycol concentration and the number of trays are held constant, some additional dew point depression may be obtainedby increasing the glycol circulation rate. However, the gain in depression will be small, usually only 5 degrees Fahrenheit, even by doubling or tripling the actual pumping rate.

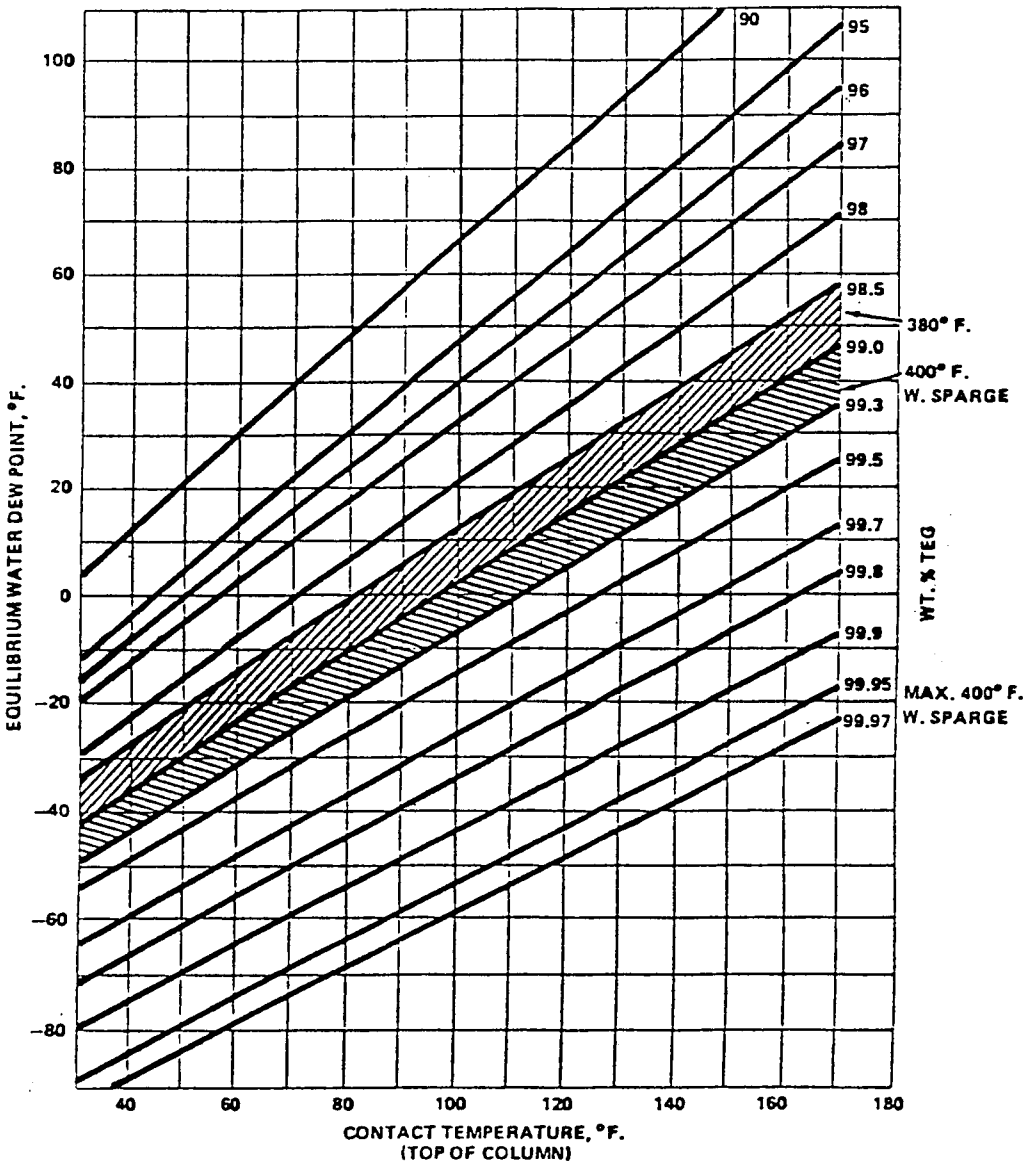
Likewise, if the glycol concentration and rate are held constant, the effect of additional trays has only a small effect on the gain in depression. However, increasing the glycol concentration above a 99.0% purity can have dramatic results on the outlet dew point obtained (Figure 1). With a 100 degree inlet gas temperature (110 degrees Fahrenheit top tray temperature), an outlet dew point of 10 degrees Fahrenheit can be obtained with 99.0% TEG. This increases to -30 degrees Fahrenheit with 99.8% TEG, and to -40 degrees Fahrenheit with 99.9% TEG. Higher concentrations of TEG can be obtained by:

- Increasing the glycol reboiler temperature.
- Injection of gas into the reboiler as it is being heated to affect a change in the partial pressure relationship of of the water still in the glycol, thus causing it to go into the gas phase and exit with the striping gas.
- Some combination of increased temperature and increased gas stripping.
- Gas stripped after the glycol has been thermaly reconcentrated and left the reboiler (known as the Stahl method).
- Specialized processes such as vacuum regeneration and the Dow DREZO process.

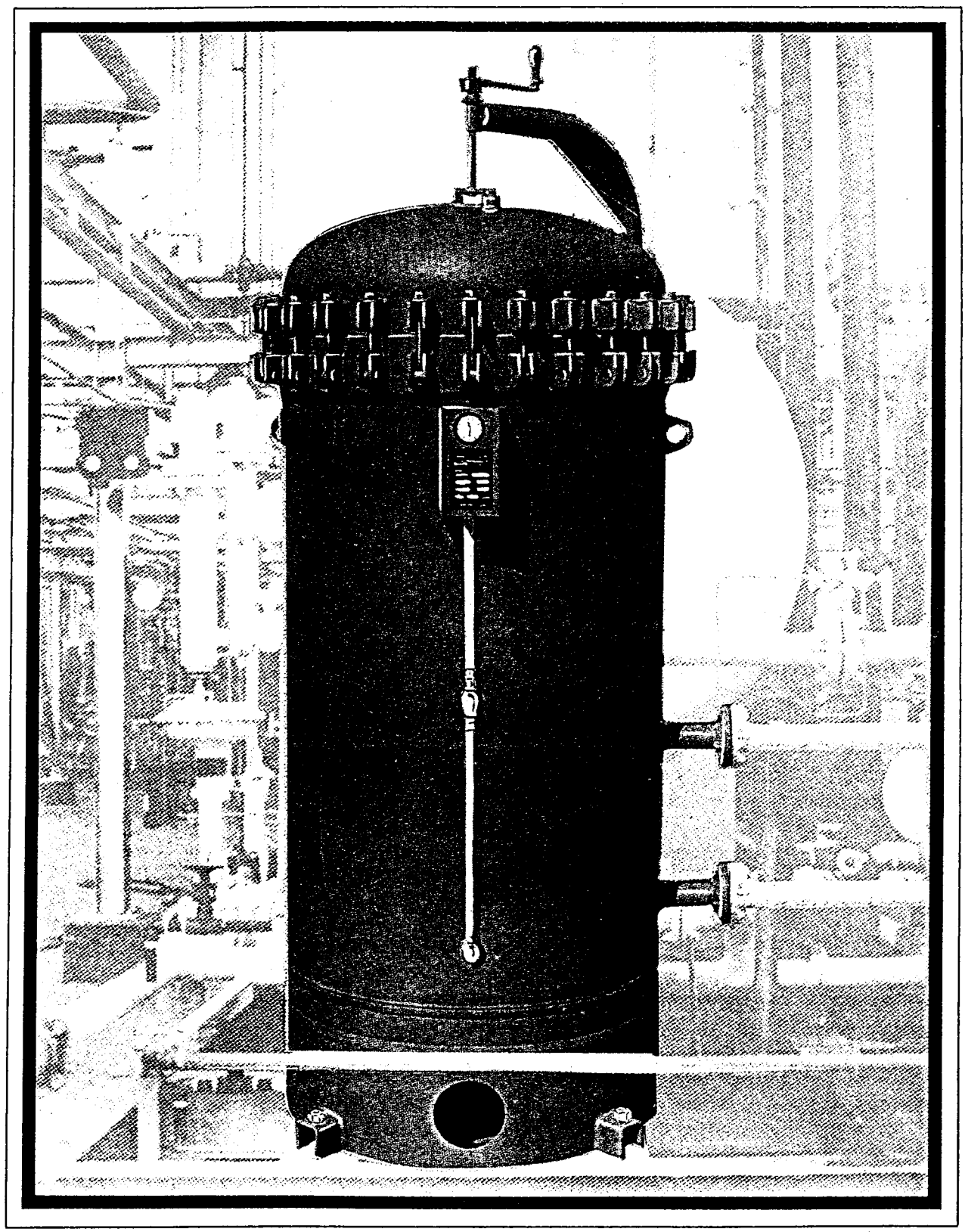
Reboiler temperatures for TEG normally run between 380 degrees Fahrenheit and 400 degrees Fahrenheit, resulting in glycol reconcentrations of 98.0% to 99.0%.

Figure 2 illustrates the effect of stripping gas. If gas is injected directly into the reboiler (via a sparger tube), the concentration of TEG increases significantly from 99.1% to near 99.6% as the gas rate is increased from 0 to about 4 scf/gal. Increasing the rate past that has negligible effect. When the Stahl method is used, concentration as high as 99.95% TEG can be attained at a 400 degree Fahrenheit reboiler temperature.

EQUILIBRIUM WATER DEW POINTS WITH
VARIOUS CONCENTRATIONS OF T.E.G.



Series 10
Activated Carbon Adsorber

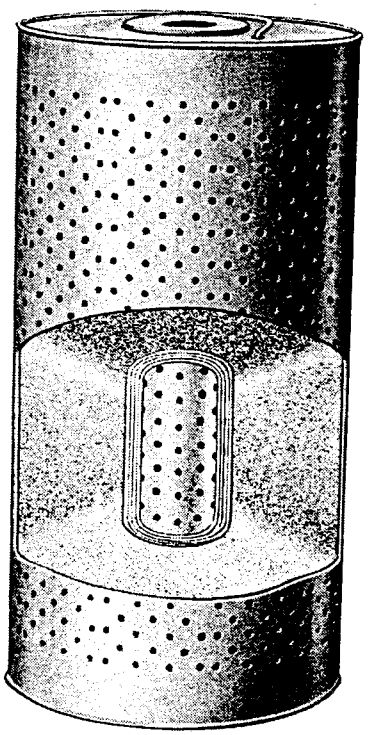


FEATURES

The Peco Series 10 Carbon Adsorber was designed primarily for purification of glycol and amine streams. It is a standard Peco quality case, constructed of carbon steel charged with scientifically engineered Peco-Char elements. Standard units are designed in vertical configuration.

MEDIA

The Peco-Char media is a granular activated carbon with a broad spectrum pore structure designed for adsorption of both high and low molecular weight liquid contaminants. Elements are available in canned, disposable units which can be easily changed by one man. Factory-packed on a vibrating machine that assures uniform carbon density, these units all have integral gaskets, core wrap and outer wrap. Bulk pack containers the same size are also available.



PECO - CHAR ELEMENT

APPLICATIONS

Although the Peco Series 10 has other uses, it was designed as a bypass or partial-flow unit. The Adsorbers are installed downstream of full-flow type solids filters to adsorb dissolved hydrocarbons, fatty acid well inhibitors and certain degradation compounds from glycol and amine systems. In-the-field studies show that the Peco Series 10 Adsorber reduces problems of foaming, fouling and corrosion and maintains consistently higher solution efficiency. Reports from the numerous installations using Peco Series 10 Adsorbers on recirculating amine streams show that foaming has been completely eliminated. The Peco-Char element has a very high capacity for removing suspended solids and adsorbing dissolved hydrocarbons that cause foaming. This reduction of foaming maintains a high unit capacity, while reducing the use of expensive anti-foaming agents.

OPERATION

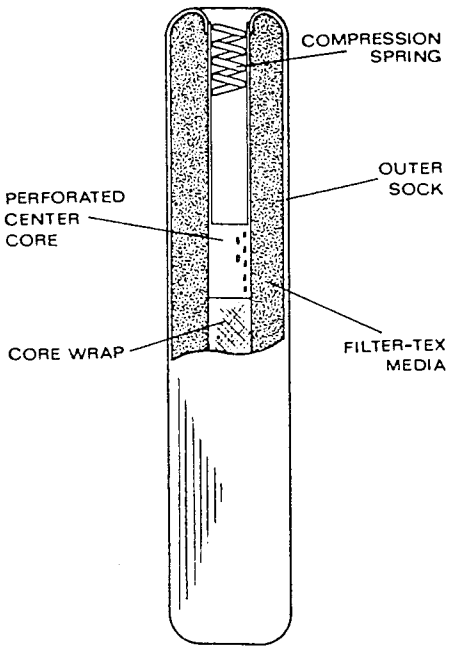
A well designed glycol dehydration or amine treating system should incorporate an efficient filter/separator (Peco Series 75) on the inlet gas stream to prevent free liquids and solid particles from entering the contactor tower. In the glycol regeneration process, a PECO Series 10 Adsorber downstream of an adequate full-flow filter removes impurities which the full-flow filter is not designed to remove. The Series 10 should flow a minimum of 5 percent of the total circulation rate and should be located on the cold, lean side of the stream.

BULK PACK REFILL

FILTER-TEX ELEMENTS

SOCK TYPE 336

PECO's Filter-Tex elements are specifically designed to give fine filtration and high contaminant retention. All Filter-Tex elements provide true depth filtration through controlled density winding of the filter media. This rolling of the filter mat onto a core makes a firm, uniform density media, creating an element that does not channel or by-pass. The irregular outer surface of the Filter-Tex material prevents surface blinding and ensures long life and full element utilization. Depth-type media offers a gradual pressure increase during the element life. This is in contrast to a surface-type media that has a rapid increase in differential pressure and an abrupt flow cut-off when loaded.



CONSTRUCTION

CENTER CORE - Carbon Steel - Corrosion Resistant

CORE WRAPS AVAILABLE - Cheese Cloth, Cerex, Remay -(Depending on media used)

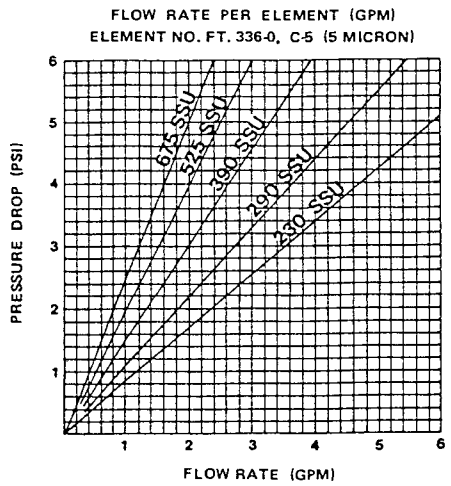
OUTER WRAPS AVAILABLE - Cotton, Orlon, Nylon, Polypropylene

SPECIFICATIONS

SIZE:	Outside Diameter	(O.D.)	3"
	Inside Diameter	(I.D.)	1-9/16"
	Length		36"
SURFACE AREA:			339.28 sq. in.

FILTER MEDIA AVAILABLE:

Filter-Tex, Blended White Cotton, Filter-Tex/Wood Fiber Blend, Cotton String, White Cotton, Polypropylene



OPERATIONAL DATA

Micron Ratings Available	5, 10, 15, 20, 25, 50, 75, 100, 125
Maximum Differential Pressure	55 PSI
Recommended Differential Pressure for Element Change	16 PSI Maximum
Efficiency at Rating	98%
Recommended Ph Rangs	2 to 10
Maximum Operating Temperature	
- for Cotton, Filter-Tex, Filter-Tex/Wood Blend and Cotton String.	300° F
- for Polpropylene	200° F

TYPICAL APPLICATIONS

MEDIA TO BE FILTERED	SUGGESTED FILTER TYPE
Amine	FT-336-C or WC-336-C
Animal, Petroleum & Vegetable Oil	FT-336-C FT-336-0
Compressor Oils	FT-336-0
Cutting Oils	FT-336-0
Dilute Alkaline	FT-336-C
Engine Fuels	FT-336-C
Glycol	FT-336-C or WC-336-C

MEDIA TO BE FILTERED	SUGGESTED FILTER TYPE
Hydraulic Oils	FT-336-0
Lube Oil	FT-336-0
Organic Solvents	FT-336-C
Quench Oil	FT-336-0
Solvents	FT-336-C
Sulfinol	CS-336-C
Water	FMP-336-0 or FT-336-C

RECOMMENDED FLOW RATES

5 MICRON ELEMENTS

FT-336-0 & C-5	MAXIMUM GPM/ELEMENT
Absorber Oil	5
Amine	3
Diesel Fuel	4
Glycol	4
Hydraulic Oil	8
Lube Oil	6
Natural Gas Liquids	6
Potassium Carbonate	3
Quench Water	5
Salt Water	5
Sulfinol	3
Varsol	3

10 MICRON ELEMENTS

FTS-336-0 & C-10	MAXIMUM GPM/ELEMENT
Amine	3
Boiler Feedwater	9
Catacarb Solution	4
Diesel	6
Hydraulic Oil	8
Hydrocarbons	6
.92 S. G. Seal Oil	5
#3 Turbine Oil at 148° F	7

SHIPPING INFORMATION

SIZE	NO. ELEMENTS / CARTON	CARTON DIMENSIONS	AVERAGE CARTON WEIGHT
336	12	12.25" x 9" x 37"	34 lbs.

ORDERING INSTRUCTIONS

FT	3	36	C	5
FILTER MEDIA CODE	DIAMETER IN INCHES	LENGTH IN INCHES	SOCK CODE	NOMINAL MICRON RATING

Code	Media
F T	Filter-Tex
FTS	Filter-Tex Blend
SF	Excelsior Fibers
FMP	Polyproplene
FGGF	Unbonded Fiberglass
WC	White Cotton
CS	Cotton String

Code	Type
C	Cotton
N	Nylon
O	Orlon
P	Polyproplene

ORDERING EXAMPLE: The part number of a Filter-Tex element 3 inches in diameter, 36" in length, with cotton sock and 5 micron rating (nominal) would be FT-336-C-5

Peco®

CORPORATE OFFICES & PLANT:
PERRY EQUIPMENT CORPORATION
Wolters Industrial Park
P.O. Box 640
Mineral Wells, Texas 76067
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Telefax: (817) 325-4622
Telex: 75-8343
TRT: 163127

HOUSTON BRANCH OFFICE:
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10649 Haddington
Suite 140
Houston, Texas 77043
Telephone: (713) 973-2575
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EUROPEAN OFFICES & PLANT:
PERRY EQUIPMENT LTD.
Rymer Point
Barnham, Thetford
Norfolk 1P24 2PN
England
Telephone: 44-842-89344
Telefax: 44-842-89350
Telex: 81611 PECO G

Series 55 Process Filters

USING 3" DIAMETER ELEMENTS 36" IN LENGTH

THE MODEL NUMBER SUCH AS 55-5-336, ETC. MEANS SERIES 55 FILTER USING FIVE 3" x 36" ELEMENTS

MODEL NUMBER	NUMBER OF ELEMENTS	SURFACE AREA FILTER MEDIA SQ. IN.	CUBIC CONTENT FILTER MEDIA CU. IN.	INTERNAL RELIEF VALVES		LIQUID TO FILL CASE	SHIPPING WT. APPROX.
				NO.	SIZE		
55 - 5-336	5	1696	899	1	A	15 gals.	250#
55 - 8-336	8	2714	1438	1	A	22 gals.	300#
55 - 11-336	11	3732	1977	1	A	30 gals.	400#
55 - 15-336	15	5089	2696	1	B	39 gals.	500#
55 - 18-336	18	6107	3236	1	B	50 gals.	650#
55 - 23-336	23	7803	4134	1	B	61 gals.	725#
55 - 29-336	29	9839	5213	1	B	74 gals.	800#
55 - 36-336	36	12214	6471	1	B	88 gals.	950#
55 - 46-336	46	15607	8269	1	B	111 gals.	1150#
55 - 58-336	58	19679	10426	1	C	137 gals.	1350#
55 - 65-336	65	22054	11684	1	C	157 gals.	1550#
55 - 71-336	71	24090	12762	1	C	177 gals.	1750#
55 - 80-336	80	27143	14380	1	D	199 gals.	1875#
55 - 110-336	110	37322	19773	2	C	270 gals.	2550#
55 - 143-336	143	48518	25704	2	D	353 gals.	3560#
55 - 191-336	191	64804	34332	2	D	446 gals.	4250#

1. Internal relief valves, when furnished, are set to open at 25 PSI differential pressure.

INSTALLATION AND OPERATING INSTRUCTIONS
SERIES 55 PROCESS FILTERS

GENERAL DATA

PECO Series 55 Filters are designed for the full flow filtration of liquid process streams, and may be furnished with or without internal differential relief valve.

Filters should be installed with by-pass and block valves to permit by-passing the filter during element changes if the stream cannot be shut down to allow element changes.

Filters are shipped from the factory complete with initial charge of elements of the proper density for the intended application.
REORDER ELEMENTS PER NAMEPLATE DATA.

INSTALLATION INSTRUCTIONS

1. Position the filter so that there is at least 38" unobstructed space above the filter for element removal.

1. Connect marked inlet and outlet connections of filter to piping of equal diameter.

3. Open the filter case and inspect it to be sure that all elements are in place and cover gasket is in proper order. Fill filter with liquid to the top and close cover. Bolt down cover securely.

4. Begin flow of liquid to filter. Vent air from case through top vent valve. Carefully check unit for leaks. Vent case at periodic intervals during operation to eleminate accumulated air.

OPERATING INSTRUCTIONS

After the filter has reached normal operating temperature, check the differential pressure across filter. Filters are normally factory equipped with pressure gauges. Regularly monitor the differential pressure reading and when it reaches 20 PSI at normal operating temperatures, the elements are loaded with contaminants and should be changed.

CHANGING ELEMENTS

1. Stop flow to filter. Bleed off pressure by opening vent valve on top of case.
2. Drain liquid to below element lower gasket seat. Under no circumstances are the elements to be removed until liquid reaches this level.
3. Remove old elements. Care should be taken that none of the contaminant on the outer surface of the old elements is accidentally dropped into the element center post.
4. Install new elements. Be sure elements are seated properly. Replace lid and bolt down evenly.
5. Begin flow to filter. Vent air from case through top vent valve. Carefully check unit for leaks. Vent case at periodic intervals during operation to to eleminate accumulated air.
6. Proceed to operate filter as described in operating instructions.

IF ANY DIFFICULTIES ARE EXPERIENCED IN INSTALLING OR OPERATING PECO FILTER, CONSULT THE FACTORY OR YOUR LOCAL REPRESENTATIVE

CORPORATE OFFICES & PLANT:
PERRY EQUIPMENT CORPORATION
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GLYCOL DEHYDRATION SYSTEM

TYPICAL OPERATING PARAMETERS

TOWER	Pressure
	Within Design
	Temperature
	Less than 125 degrees F, 80 degrees
	to 110 degrees F Ideal
REBOILER	Temperature
	350 degrees to 400 degrees F
SURGE	Fill Level
	1/2 to 2/3 full
STILL COLUMN	Temperature
	215 degrees to 225 degrees F
GLYCOL CIRCULATION RATE	Approximately 3 gal./lb. H_2O removed
GLYCOL-CONDENSATE-GAS SEPARATOR	Pressure
	50 - 75 lbs.
	Temperature
	100 degrees - 150 degrees F
FILTER ELEMENT REPLACEMENT	Sock
	30 day or 20 psi differential
	whichever comes first
	Carbon
	Cartridge: 45 - 60 days
	Bulk: 90 - 180 days
PUMP STRAINERS	Clean
	30 days
WATER CONTENT	Gas
	Pipeline Specifications
	(4 - 7 lbs./MMSCF)
GLYCOL LOSSES	Ideal Operating Conditions
	1/10 gal./day/MMSCF/D,
	normal conditions

GLYCOL ANALYSIS INTERPRETATION

Analysis is a key diagnostic tool in troubleshooting and preventative maintenance. A complete glycol analysis of lean and rich samples, when properly interpreted, can provide a detailed picture of the internal workings of the dehydration unit and it's process. This picture highlights problems and potential problems. Although individual values for specific tests can indicate system trouble spots, it is the relationship between the values of combined tests which, when coupled with physical data, can pinpoint problems and predict failures.

pH

The pH of a sample indicates the acidity or alkalinity of the glycol. pH is the measurement of hydrogen ion concentration and is noted on a scale ranging from zero to fourteen with seven indicating a neutral point. Below seven is considered acidic and above seven is considered alkaline. The pH of glycol ideally should be between 7 and 8.5, however a range of 6 to 9 is acceptable. A pH below 6 will generally correspond with system contamination, corrosion, and/or oxidation. Whenever glycol pH reaches 5.5 autoxidation occurs. Autoxidation is the chemical decomposition of the glycol within itself. In other words, when the glycol's pH drops to 5.5 it has the tendency to continue to drop without outside influences. Some causes of low pH, in addition to autoxidation, are acid gases (H_2S and CO_2) in the gas stream, organic acids due to oxidation or thermal degredation, excessive chlorides (salt) in the glycol, well treating chemicals entrained in the gas stream, thermal decomposition of entrained in the gas stream, thermal decomposition of entrained liquid hydrocarbons in the glycol and oxidation of the glycol due to improper storage. pH is a good indicator of corrosion within the system. For every full point reduction of pH below 7, the corrosion rate of steel will approximately double. As mentioned elsewhere in this text, corrosion is measured in mils per year or MPY. It is acceptable to have a corrosion rate not exceeding 6 MPY. When a pH of 6 is found to have a corrosion rate of 5 MPY then a drop in pH to 5 will translate into a corrosion rate of 10 MPY. A subsequent drop to a pH of 4 will increase corrosion to 20 MPY and soforth. pH can be raised through the use of inhibitors or buffers (see Corrosion Page 51). High pH is usually a result of contamination from well treating chemicals entrained in the gas stream or an overdose of neutralizer added to a system for low pH. Foaming tendencies can result from high pH. This is primarily due to stabilized glycol-hydrocarbon emulsions. Sludge and residue build-up can result from both high and low pH. This sludge may become abrasive and cause premature pump and valve failure. It may also deposit in trays and downcomers, still column packing and heat exchangers causing system plugging.

HYDROCARBON

Natural gas, as it is produced form its native underground environment, carries with it vapor and liquid phase hydrocarbons ranging from light, low molecular weight oils to heavy, high molecular weight oils and organic residues. These hydrocarbons often enter the glycol stream as a result of carry-over from a separator or as condensation due to temperature variation. In addition, compressor lube oils and other extraneous organic chemicals such as pipeline corrosion inhibitors, often are stripped out of natural gas as it traverses the intimate contact areas of the glycol tower. These oils and organic residues can cause severe glycol/ water emulsions and suspensions which contribute to foaming.This results in excessively high glycol carry-over from the contactor. When chemically and thermally decomposed these contaminants may cause plugging in the contactor, still column and heat exchangers.

Light hydrocarbons are usually separable from a glycol stream given a little added heat and some quiescent settling time in an adequately sized glycol/hydrocarbon skimmer-separator. Heavy hydrocarbons are less manageable and must be filtered out, typically with activated carbon. The heavier hydrocarbons are generally referred to as "soluble" hydrocarbons because of their tenacious bonding with the glycol. Glycol, being a hydrocarbon dirivitive has a natural affinity for some hydrocarbons.

Light end hydrocarbons (insolubles) in the glycol sample are allowable up to 1% by volume. The soluble or entrained hydrocarbons are only acceptable to .1% by weight. This shows how troublesome the heavier entrained hydrocarbons can be. They are primarily responsible for foaming, sludge and residue build-up, low pH, loss of hygroscopicity, and glycol decomposition. Excessive hydrocarbons in a glycol sample may be indicative of carry-over (either free liquid or mist generated by turbulance). Water content, chlorides, and iron values may confirm this. However, high values for hydrocarbon may also result from inadequate filtration and poor filter maintenance. Look at results obtained for suspended solids and residue (and possibly foaming) to aid in this determination.

WATER CONTENT (ALSO GLYCOL % OR PURITY)

Water content is the quantity of water in the glycol solution. The difference between the lean sample and rich sample measures the degree of loading in the contactor. It also indicates regeneration efficiency. Ideally, glycol purity should be 98% or higher in the lean stream and 94% or higher in the rich. Put another way, the rich glycol should have no more than 6% water and the lean glycol should have 2% or less. These concentrations will produce the desired dew points in systems which are operating properly. For lower dew points the purity must be increased (or water content decreased).

High water content of the lean sample generally indicates low reboiler heat. It may also indicate any of the following:

1. Excessive glycol circulation.
2. Undersized equipment.
3. Carry-over from the separator.
4. Vapor communication from reboiler to surge.
5. A leak in the glycol to glycol heat exchanger.
6. Over refluxing in the still column.
7. Hot inlet gas temperature.

High water content for the rich sample usually indicates a low glycol circulation rate, however it may also be attributed to:

1. Carry-over form the separator.
2. Poor reconcentration.
3. Heat exchanger communication.
4. Undersized equipment.
5. Hot inlet gas temperature.

Check values for hydrocarbon, chlorides, iron and foaming to help pinpoint the problem.

SUSPENDED SOLIDS

Suspended solids are considered to be those solids and tarry hydrocarbons which remain suspended within the glycol solution down to .45 micron in size. They are the result of poor inlet separation, corrosion, and thermal degredation of the glycol. Values obtained for suspended solids greater than .01% by weight indicate poor sock filtration. Most glycol units will utilize elements capable of filtering particles to a size of 5 micron. Particles larger than this in excessive amounts may serve to stabilize foaming tendencies in glycol. When the glycol is allowed to maintain a large concentration of suspended solids a silty residue is likely to form along vessel walls. Plugging of the contactor trays, heat exchangers, still column, and reboiler glycol outlet is likely. This particularly common in systems with low glycol pH. Premature heat tube failure is also a possibility.

RESIDUE

The value for residue is a function of system contamination. The glycol sample is distilled, removing all light end hydrocarbons, water and glycol. The residue represents the remaining contamination. This contamination is comprised of total solids (suspended and residual), salt, and heavy hydrocarbons. The value for residue is best kept below 2% by weight, however some systems may operate reasonably well at values from 2% to 4%. Units with glycol containing greater than 4% are prime candidates for failure and should be cleaned immediately.

CHLORIDES

Chloride values indicate the quantity of inorganic chlorides (salts) found in the glycol sample. The analysis results may be written in parts per million (ppm) or milligrams pre liter (mg/1). These units of measure are interchangeable.

Most of the time the salt found in glycol will consist of sodium chloride (NaCl) but calcium chloride may also be present. The salt is deposited in the contact tower from free produced water swept in with the gas. This occurs either as a liquid carry-over or as a mist created by turbulence through the separator or inlet scrubber.

As the concentration of chlorides (as NaCl) in glycol increases, its solubility decreases. The solubility also decreases when heat is added to the glycol solution. When the solublility decreases the salt begins to form crystals. These crystalls fall out of the glycol solution. They accumulate on the heat source and can lead to premature heat tube failure. Crystals formed by precipitation of chlorides may be swept by the glycol into other areas of the system. Potential problems associated with excessive chlorides include system plugging, low pH, glycol pump damage, foaming and loss of hygroscopicity due to rapid glycol decomposition. Removal of chlorides in high concentration requires vacuum distillation of the glycol. Although filtration will remove large salt crystals, most of the damage associated with salt will have already occured prior to the development of crystals large enough to filter.

In concentration greater than 1000 ppm chlorides will stabilize foaming tendencies. This may lead to excessive glycol loss. This concentration may also affect glycol pH. Precipitation of salts from the glycol will initiate at approximately 1200 to 1500 ppm, however the crystals formed are extremely small and rarely troublesome. At concentrations above 2200 ppm precipitation occurs readily and system failure is a possibility.

IRON

Iron found in glycol samples can indicate possible corrosion. It may also be an indicator of produced water carry-over. Iron in excess of 50 ppm generally indicates corrosion. Whether it be in the glycol unit, upstream in the production equipment, or downhole in the well string is difficult to determine. Comparing values for pH, chlorides, and visual inspection of the glycol unit may help to extablish the location of suspected corrosion. Corrosion by-products will consist of soluble iron and fine, gritty particulate in systems where oxygen is available. In systems where no oxygen is present corrosion by-products will include sulfides in addition to the iron.

FOAMING

More glycol is lost through foaming than any other cause. Since foaming is not easily detected without lab analysis, gradual low volume glycol loss often goes overlooked. Losses

may be two or three times normal without causing alarm to the operators. Over an extended period of time this loss becomes very expensive.

Foaming is almost always a result of contamination. Occasionally, gas content may effect foaming but this is rare. The primary contaminants that cause foaming are hydrocarbons (from separator carry-over) and solids. However chlorides, compressor lube, well treating chemicals and iron also promote foaming. Water content will affect foaming tendencies by inducing emulsification of contaminants, particularly hydrocarbons. Carbon filtration has been proven to be the most effective means of controlling foam by removing the contamination or source of the foaming. In cases where carbon filtration is not enough or not economically sound to use, a silicone emulsion type foam inhibitor may be used. Foam inhibitors treat the symptom not the cause and thus are temporary solutions. Addressing the source of the contamination causing the foam is the only long term solution.

The foam test consists of bubbling dry air at a rate of 6 liters per minute through a graduated cylinder containing 200 milliliters of the glycol sample until the foam stabilizes at its maximum height. The volume for both the liquid and the foam is reported as a single value. The original 200 M/L is then subtracted. The remaining value is recorded as height and represents the ease at which the solution will foam. Once the maximum foam height is recorded, the dry air is removed from the sample and the time it takes for the foam to break from its maximum volume to a clear surface on the glycol sample is recorded in seconds. This time represents the tenacity of the foam and is known as stability. Foam tendency is measured in height and stability.

There are no concrete values given for acceptable foam height and stability. Foam with very low height and moderate stability will result in little glycol loss as will a foam with moderate height and very low stability. Therefore we show the acceptable range for foam test results as such:

height/ml	20 ml-----> 30 ml
stability/sec.	15 sec< -----5 sec

This represents the increasing and decreasing values of acceptability for each. For example, a sample with a height of 25 ml and a stability of 10 sec. would be acceptable, A sample with 30 ml height and 15 sec. stability would have slightly high foaming tendencies and could result in glycol loss.

SPECIFIC GRAVITY

The specific gravity of glycol is an approximate indication of its weight percent. It is used to determine the purity of the glycol. A specific gravity of 1.126 to 1.128 at 60 degrees Fahrenheit would indicate 99% TEG (technical grade). A specific gravity of 1.124 to 1.126 indicates 97% TEG (industrial grade). For glycol extracted from an operating dehy unit the

lean sample should have a specific gravity of 1.118 to 1.121. This variance allows for acceptable amounts of system contamination. A high specific gravity indicates the system is contaminated with excessive amounts of solids or any additives with a greater density than glycol. Low specific gravity could indicate one or more of the following:

1. T.E.G. containing excessive amounts of E.G. and/or D.E.G.(poor quality replacement glycol).
2. Excessive water in the sample.
3. Excessive hydrocarbons in the sample.
4. Thermal degredation of the glycol.
5. Oxidation or chemical degredation of the glycol.

GLYCOL COMPOSITION

Glycol composition indicates glycol quality. Values are given to the component glycols (EG, DEG, TEG, TTEG) contained within the glycol sample solution. Usually industrial grade (97%) TEG or better is required for the best glycol system results. In addition to 97% TEG the glycol solution may contain in various combinations up to 1.0% EG and 3.0% DEG but not to exceed a combined total of 3%. Glycol degredation will often be reflected by changes in the glycol composition and reduction in pH. Thermal degredation is most common. It is characterized by excessive values for EG, DEG, and occasionally the presence of TTEG. The glycol pH will be low. The glycol sample will be dark and have an aromatic smell, similar to rotten bananas. Chemical degredation is brought about by oxidation and acidic contaminants. Chemical degredation will be characterized by excessive values for EG and DEG but no TTEG will be present. The pH will be low. The glycol may not appear to be too dirty. Autoxidation is a form of continuing chemical degredation.

DETERMINING GLYCOL CIRCULATION RATE

Step I

Note the daily volume of gas to be dehydrated and at what temperature and pressure it is entering the contactor.

Step II

With the known values for pressure and temperature use, the saturation graph to determine how much water is contained in one (1) mmscf/gas.

Step III

Subtract the allowable water per mmscf/gas from the total water per mmscf/gas to determine the amount of water per mmscf/gas to be removed.

Step IV

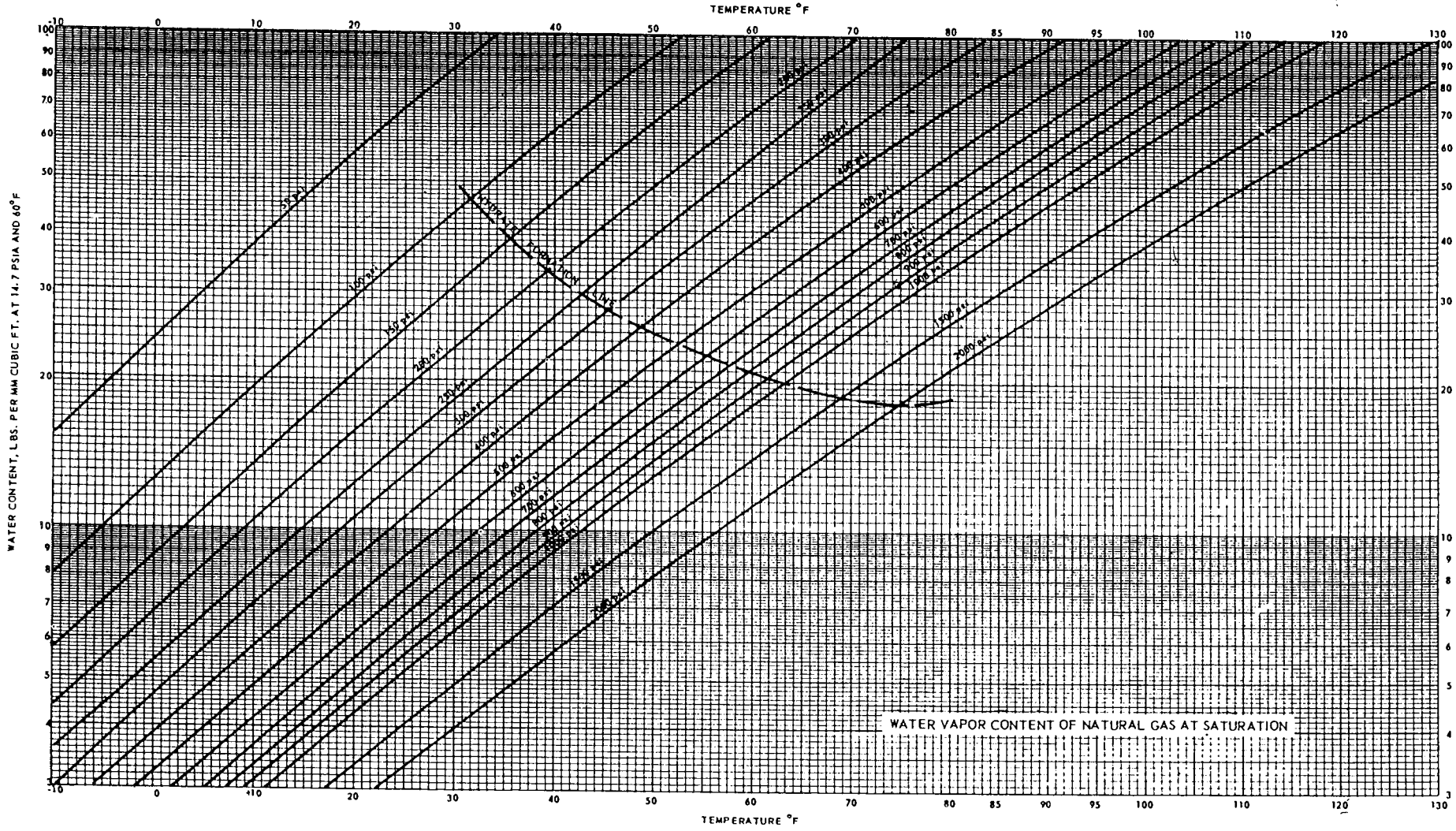
Multiply the total water to be removed per mmscf/gas times the daily volume of gas (in mmscf) to determine the total amount of water to be removed per day.

Step V

Multiply the total amount of water to be removed per day times the contactor design circulation rate (usually 3 gallons glycol per 1 pound of water) to determine the total amount of glycol to be circulated per day.

Step VI

Divide the daily glycol circulation rate by 24 to determine the hourly circulation rate.


TEMPERATURE °F
WATER CONTENT, LBS. PER MM CUBIC FT. AT 14.7 PSIA AND 60°F
WATER VAPOR CONTENT OF NATURAL GAS AT SATURATION
TEMPERATURE °F

1) mmscf/d gas _____ Pressure _____ Temperature _____

2) Saturation Graph

Pressure _____

Temperature _____

H_2O per mmscf/gas _____

3) H_2O per mmscf/gas _____ − Allowable H_2O _____ = H_2O to be removed pre mmscf/gas _____

4) H_2O/mmscf to be removed _____ × mmscf/d gas _____ = Total H_2O to be removed _____

5) H_2O/d to be removed _____ × Contactor design rate _____ = Total glycol/d circulation rate _____

6) Daily glycol rate _____ ÷ 24 = Hourly glycol rate _____

SETTING GLYCOL PUMPS FOR CALCULATED CIRCULATION RATE NEEDED

A. KIMRAY GLYCOL POWERED PUMPS

1. Determine strokes per minute for your model pump from Appendix "D" to give the calculated gallons per hour glycol circulation rate.
   EXAMPLE: One Kimray Model 45015 Pump. For 336 gallons per hour, 20 strokes per minute required.
2. Adjust pump to give number of strokes per minute determined from Appendix "D". In counting strokes, count one stroke for each direction.
3. If it is desired to operate two glycol pumps at the same time, divide the calculated glycol circulation rate by 2 and repeat 1 above.

B. ELECTRIC POWERED PUMPS

1. Many equipped with positive displacement meter. With this type installation, read number of gallons metered in one minute and multiply by 60 to determine gallons per hour rate.
2. If no meter is provided, the glycol circulation rate can be determined in the following manner:

   Step a. With pump(s) running temporarily, close the block valve on the contactor wet glycol dump line.

   Step b. Measure the number of inches rise of the glycol level in the contactor gauge glass for 5 minutes. Then open glycol dump line block valve.

   Step c. Note the contactor internal diameter in inches as stamped on the contactor date name plate.

   Step d. Multiply value obtained in Step c. by itself.

   Step e. Multiply value obtained in Step d. by .041.

   Step f. Multiply value obtained in Step e. by value obtained in Step b.

   EXAMPLE: Step b. Glycol level rise in gauge glass = 4 inches.
   Step c. Contactor Internal Diameter = 60 inches.
   Step d. Step c. × itself = 60 × 60 = 3600
   Step e. Step d × 0.041 = 3600 × .041 = 148
   Step f. Step e. × Step b. = 148 × 4 = 592 gal/hr.

   If the calculated flow rate is different than that desired, adjust the pumping rate, allow 15 - 30 minutes for the new circulation flow rate to stabilize, and repeat the above rate determination.

PRESSURE-TEMPERATURE CURVES FOR PREDICTING HYDRATE FORMATION

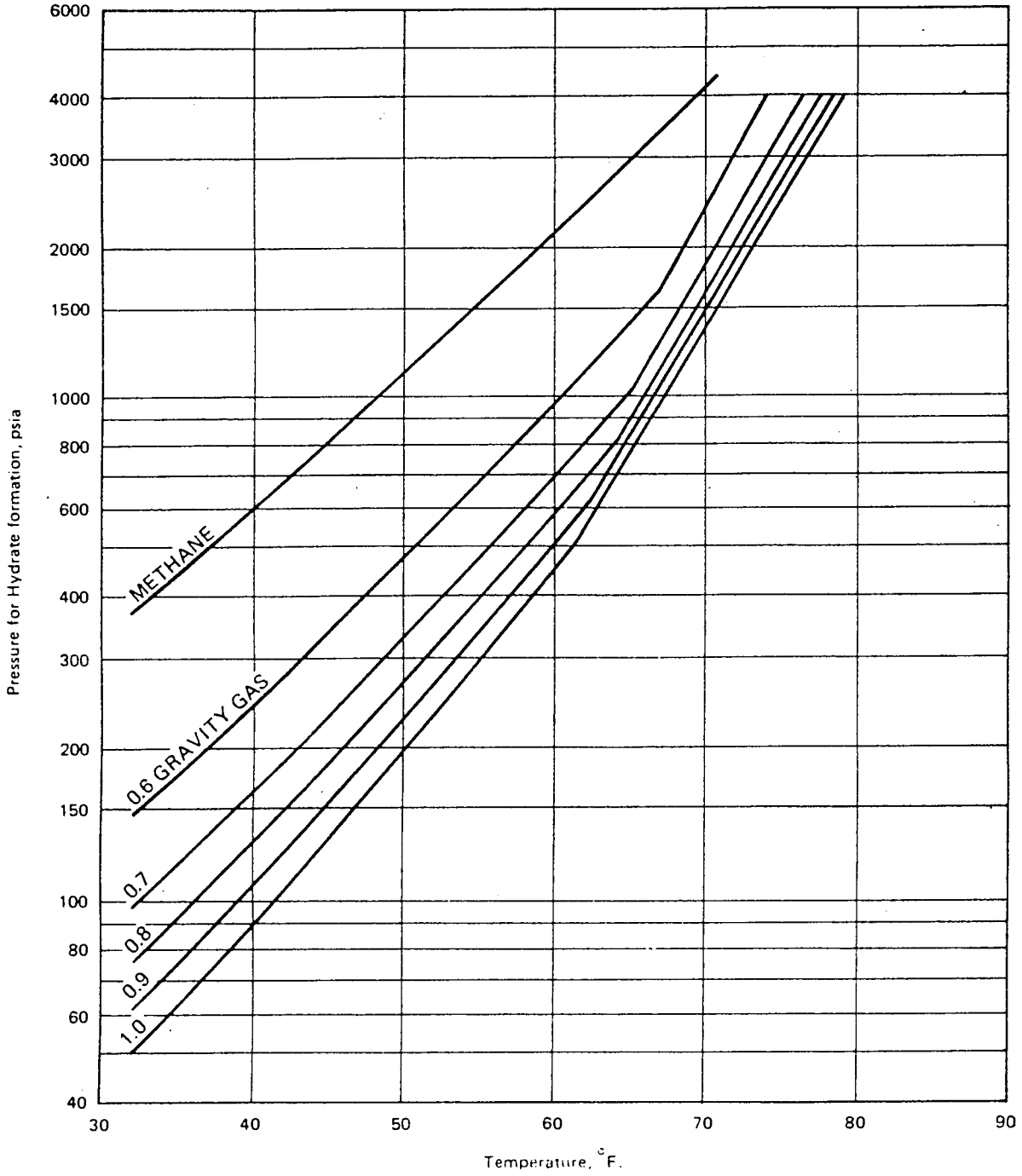
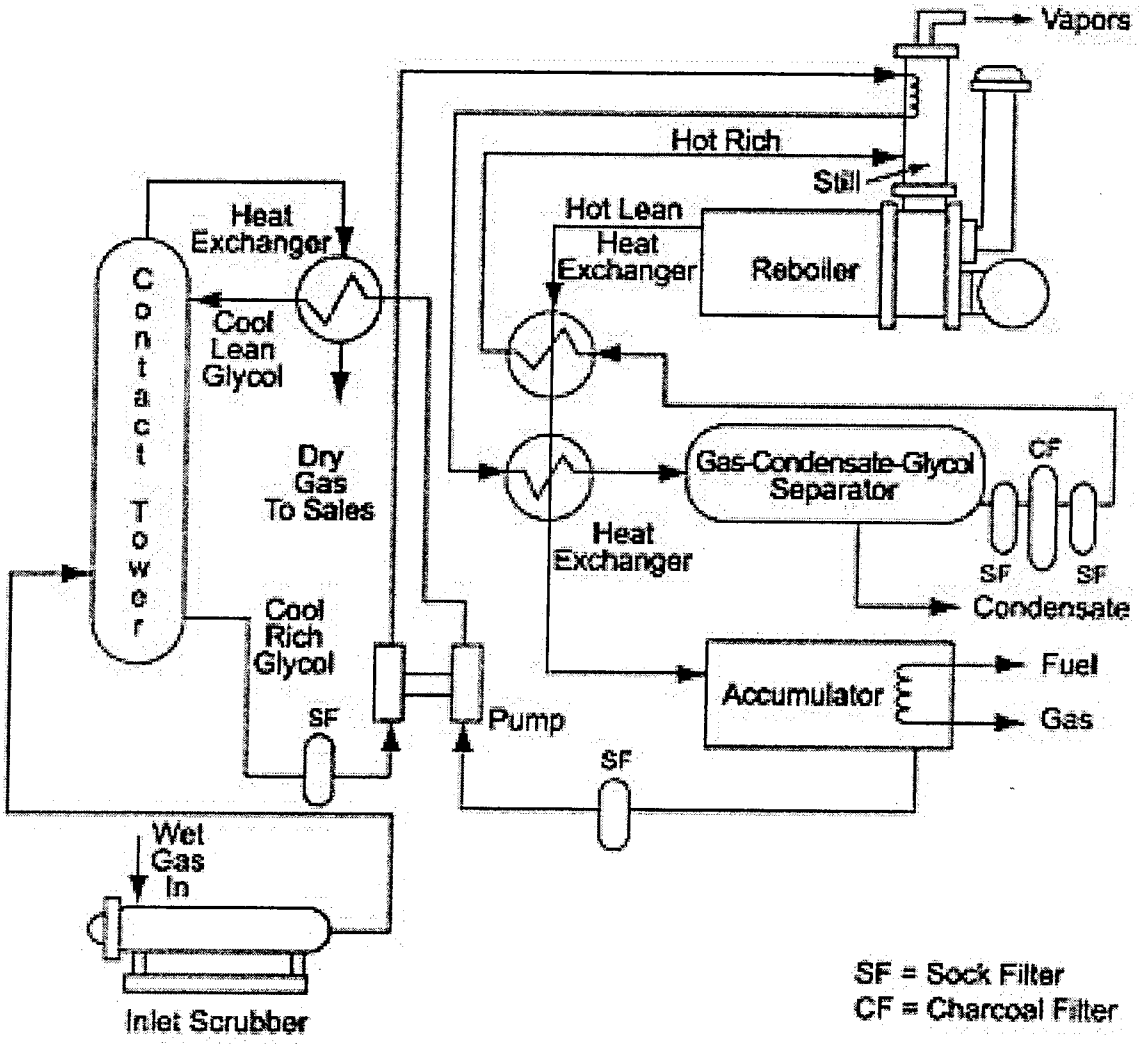


Exhibit 1
Glycol Dehydration Process Flows



EQUILIBRIUM WATER DEW POINTS WITH VARIOUS CONCENTRATIONS OF TEG

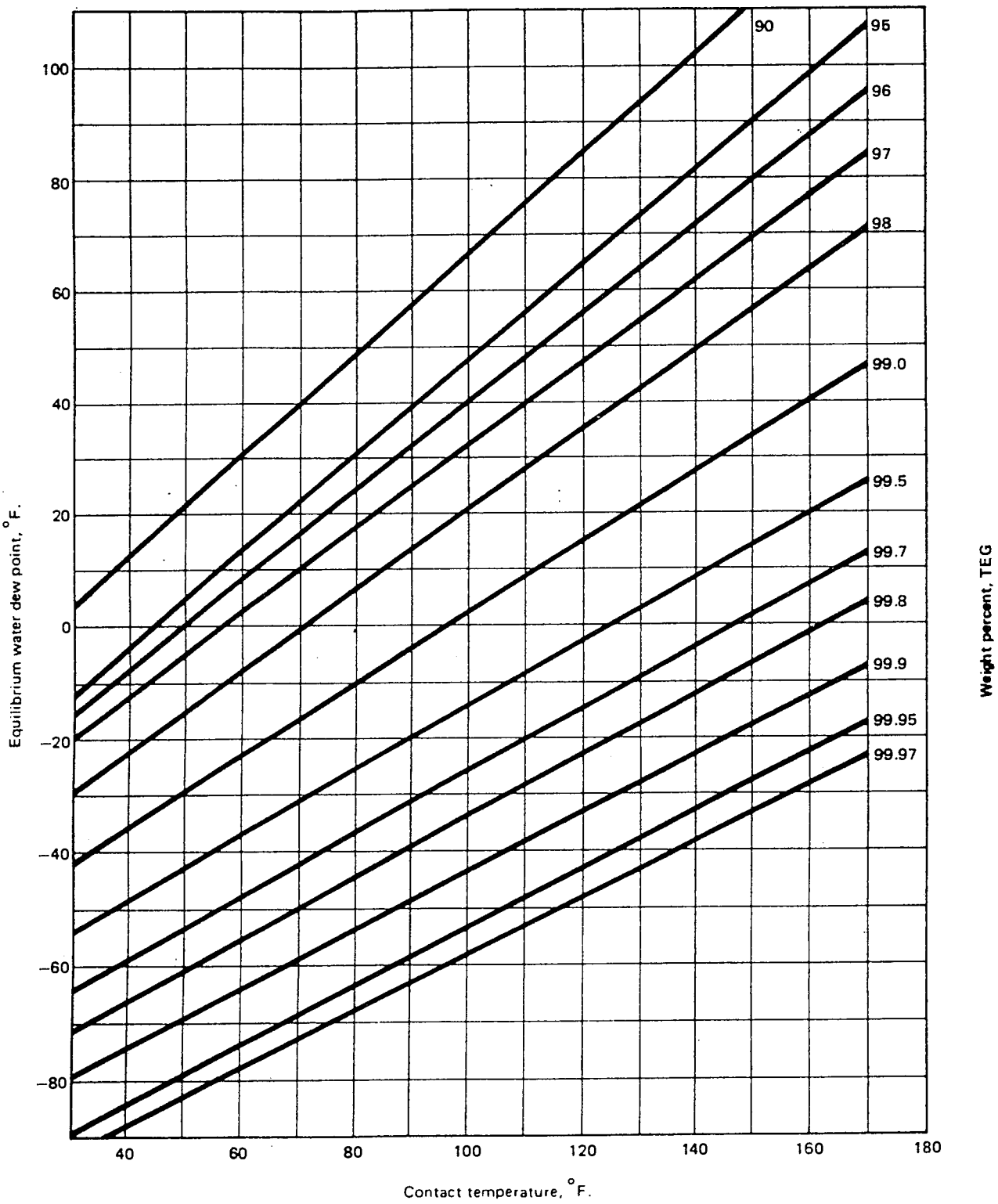
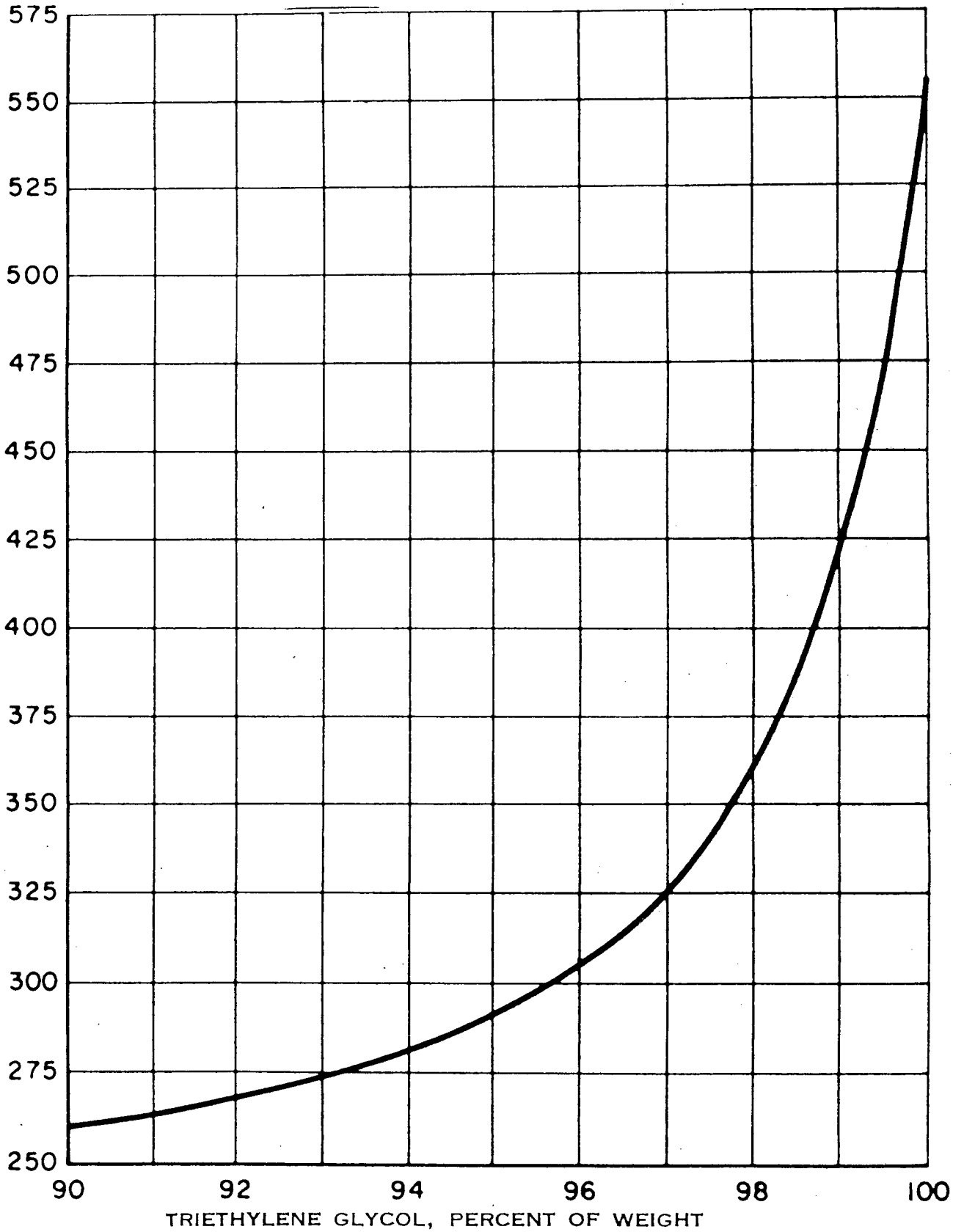


FIGURE 3

BOILING POINTS OF AQUEOUS COMMERCIAL GRADE TRIETHYLENE GLYCOL SOLUTIONS

(760) MM. HG PRESSURE



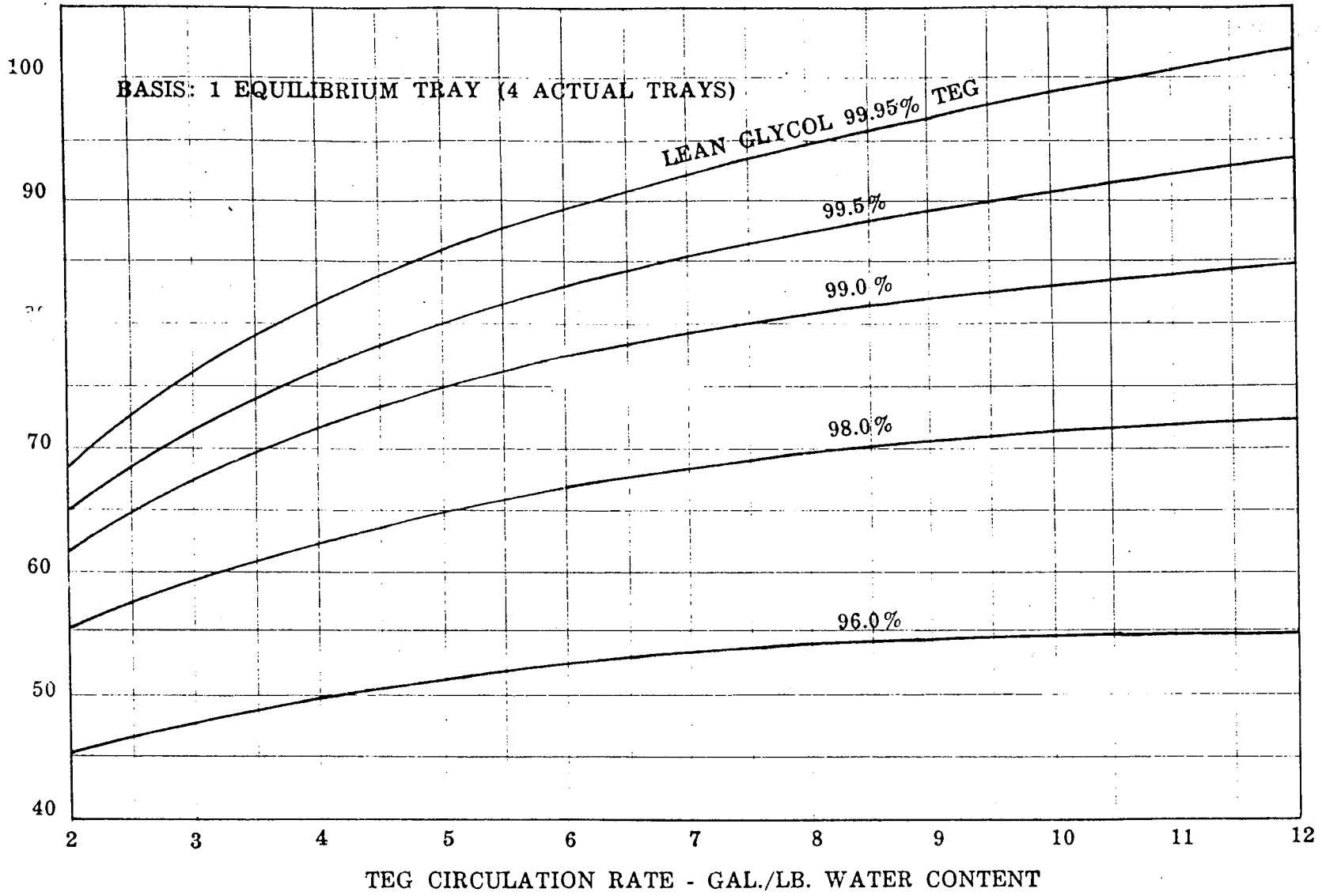


FIGURE 5

CALCULATED DEW POINT DEPRESSION VS
TRIETHYLENE GLYCOL CIRCULATION RATE

CASE STUDY #1

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	8.49	7.73	7.0 - 8.5
H_2O (wt. %)	1.4	1.8	1 - 2% lean, 6% rich
Residue (Wt. %)	2.2	1.8	4% total
Chlorides (mg/L)	750	875	1000
Suspended Solids	<.01	<.01	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	.05	.03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	375 °F
Reflux Col. Temp.	215 °F
Pump Circulation	56.6 GPH (based on 2 gal TEG/LB H_2O removed)
Filter DP	<15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	1440 PSIG
Inlet Temp	100 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	~47 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	~ 40 LB/MMSCF
Gas Comp.	.7 specific gravity

DEW POINT DEPRESSION	65°
DEW POINT	7 LB/MMSCF

CASE 1 CONT'D

PROBLEM STATEMENT: Excess glycol consumption (14 gallons / day).
OBSERVATIONS: Glycol present at point of sale.
ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

CASE STUDY #2

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	7.70	7.73	7.0 - 8.5
H_2O (wt. %)	1.4	1.8	1 - 2% lean, 6% rich
Residue (Wt. %)	7	4	4% total
Chlorides (mg/L)	750	875	1000
Suspended Solids	.7	.1	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	.05	.03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	375 °F
Reflux Col. Temp.	215 °F
Pump Circulation	6.6 GPH (maximum)
Filter DP	>15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	1440 PSIG
Inlet Temp	100 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	~47 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	~ 40 LB/MMSCF
Gas Comp.	.7 specific gravity with trace CO_2

DEW POINT DEPRESSION	65°
DEW POINT	7 LB/MMSCF

CASE 2 CONT'D

PROBLEM STATEMENT: Reduced attainable glycol circulation and glycol loss.
OBSERVATIONS: Severely corroded still column, discolored and smelly glycol odor. Pump starvation and some glycol found at the point of sale. Note: visual inspection revealed some tray fouling but not enough to cause lost circulation.
ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

CASE STUDY #3

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	7.70	7.73	7.0 - 8.5
H_2O (wt. %)	4.4	6.8	1 - 2% lean, 6% rich
Residue (Wt. %)	7	4	4% total
Chlorides (mg/L)	1750	1875	1000
Suspended Solids	.7	.1	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	05	03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	360 °F
Reflux Col. Temp.	160 °F
Pump Circulation	56.6 GPH (maximum)
Filter DP	<15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	1440 PSIG
Inlet Temp	100 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	~47 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	~ 40 LB/MMSCF
Gas Comp.	.7 specific gravity with trace CO_2

DEW POINT DEPRESSION	65° (unobtainable)
DEW POINT	27 LB/MMSCF

CASE 3 CONT'D

PROBLEM STATEMENT: High dew points and glycol loss.

OBSERVATIONS: Reflux coils in bypass. Reboiler spewing glycol. Glycol discoloration and abnormal odor.

ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

CASE STUDY #4

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	7.70	7.73	7.0 - 8.5
H_2O (wt. %)	2.5	8	1 - 2% lean, 6% rich
Residue (Wt. %)	7	4	4% total
Chlorides (mg/L)	750	875	1000
Suspended Solids	.7	.1	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	.05	.03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	375 °F
Reflux Col. Temp.	215 °F
Pump Circulation	90 GPH (maximum)
Filter DP	<15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	700 PSIG
Inlet Temp	100 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	≃ 65 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	≃ 58 LB/MMSCF
Gas Comp.	.7 specific gravity with trace CO_2

DEW POINT DEPRESSION	65°
DEW POINT	10 LB/MMSCF

CASE 4 CONT'D

PROBLEM STATEMENT: High dew points and marginal glycol loss.
OBSERVATIONS: Some glycol observed at point of sale.
ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

CASE STUDY #5

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	7.70	7.73	7.0 - 8.5
H_2O (wt. %)	1.04	2.05	1 - 2% lean, 6% rich
Residue (Wt. %)	7	4	4% total
Chlorides (mg/L)	750	875	1000
Suspended Solids	.7	.1	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	.05	.03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	275 °F
Reflux Col. Temp.	215 °F
Pump Circulation	54 GPH
Filter DP	<15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	1000 PSIG
Inlet Temp	80 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	≃ 34 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	≃ 27 LB/MMSCF
Gas Comp.	.7 specific gravity with trace CO_2

DEW POINT DEPRESSION	65°
DEW POINT	7 LB/MMSCF

CASE 5 CONT'D

PROBLEM STATEMENT: Glycol loss (51 gallons / month)
OBSERVATIONS: System appears to be operating properly.
ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

CASE STUDY #6

EQUIPMENT SIZE

TOWER: 30" diameter X 17' 6" seam to seam, 4 trays with integral scrubber and external heat exchanger.
RECONCENTRATOR: 250,000 Btu/Hr
PUMP SIZE: KR 9015
MAXIMUM PUMP RATE: 90 GPH

DESIGN CONDITIONS

INLET PRESSURE	1440 PSIG
INLET TEMP	100 ° F
MAXIMUM FLOW	23MMSCF/D

ACTUAL CONDITIONS

GLYCOL ANALYSIS	LEAN	RICH	ACCEPTABLE
Specific Gravity	1.126	1.124	1.118 - 1.122
pH	8.49	7.73	7.0 - 8.5
H_2O (wt. %)	1.04	2.45	1 - 2% lean, 6% rich
Residue (Wt. %)	2.2	1.8	4% total
Chlorides (mg/L)	750	875	1000
Suspended Solids	<.01	<.01	.01%
Foam			
Height (ml)	<5	<5	20 - 30
Stability (sec)	1	3	5 - 15
Hydrocarbon (Wt. %)	.05	.03	.1% lean
Iron (PPM)	trace	trace	50

OPERATING CONDITIONS

RECONCENTRATOR	
Reboiler Temp.	375 °F
Reflux Col. Temp.	215 °F
Pump Circulation	54 GPH
Filter DP	<15 PSID
Skimmer Temp	100 °F
Skimmer Pressure	75 PSIG
TOWER	
Inlet Pressure	1000 PSIG
Inlet Temp	80 °F
Flow Rate (GAS)	17 MMSCF/D
H_2O Content	≃ 34 LB/MMSCF
Contract H_2O	7 LB/MMSCF
H_2O to be removed	≃ 27 LB/MMSCF
Gas Comp.	.7 specific gravity with trace CO_2

DEW POINT DEPRESSION	65°
DEW POINT	7 LB/MMSCF

CASE 6 CONT'D

PROBLEM STATEMENT: Severe glycol losses.

OBSERVATIONS: System appears to operate normally except for losses which continue even with skimmer in by pass. No glycol is observed at the point of sale. Only negligible amounts being lost at still column.

ACTION: Troubleshoot system to determine probable cause or causes. Detail procedure used to isolate and confirm problem. Indicate revenue losses associated with the problem. And, indicate loss control procedures.

TRIETHYLENE GLYCOL

SECTION I
FIRE AND EXPLOSION DATA

lash Point(Closed Cup): 342.00 DEG F (172.22 DEG C)

ower Explosive Limit: (Product) .9%

xtinguishing Media: Alcohol foam or water fog or carbon dioxide or dry chemical.

azardous Decomposition Products: May form toxic materials; carbon dioxide and carbon monoxide.

pecial Firefighting Procedures: Self-breathing apparatus with a full facepiece operated in pressure-mand or other positive pressure mode.

nusual Fire & Explosion Hazards: Never use welding or cutting torch on or near drum (even empty) because product (even just residue) can ignite explosively.

SECTION II
HEALTH HAZARD DATA

reshold Limit Value: Not established.

rf s of Overexposure: For product
- Eyes - May cause irritation.
- Skin - May cause irritation.
- Breathing - Of mist can cause irritation or nasal and respiratory passages.
- Swallowing - May cause gastrointestinal irritation.

irst Aid:

If on skin: Thoroughly wash exposed area with soap and water. Remove contaminated clothing. Launder contaminated clothing before re-use.

If in eyes: Flush with large amounts of water, lifting upper and lower lids occasionally.

If swallowed: Give two glasses of water; induce vomiting immediately by sticking finger down throat. Call a physician. Never give anything by mouth to an unconscious person.

reathed: If affected, remove individual to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped give artificial respiration. Keep person warm, quiet and get medical

SECTION III
REACTIVITY DATA

Hazardous Polymerization: Cannot occur

Stability: Stable

Incompatability: Avoid contact with; strong oxidizing agents.

SECTION IV
SPILL OR LEAK PROCEDURES

Steps to be taken in case material is release or spilled:

Small Spill: Absorb liquid on paper, vermiculite, floor absorbent, or other absorbent material and transfer to hood

Large Spill: Eliminate all ignition sources (flares, flames including pilot light electrical sparks). Persons not wearing protective equipment should be excluded from area of spill until clean up has been completed. Stop spill at source, dike area of spill to prevent spreading, pump liquid to salvage tar Remaining liquid may be taken up on clay, earth, floor absorbent, or other absorbent material and shoveled into containers. Prevent run-off to sewers streams, or other bodies of water.

Waste Disposal Method:

Small Spill: Destroy by incineration.

Large Spill: Destroy by liquid incineration Contaminated absorbent may be deposit in a landfill in accordance with local state and federal regulations.

MATERIAL SAFETY DATA

TRIETHYLENE GLYCOL (CONT'D)

SECTION V
PROTECTIVE EQUIPMENT TO BE USED

Respiratory Protection: If overexposure has been determined or documented a NIOSH/MSHA jointly approved air supplied respirator is advised in absence of proper environmental control. OSHA regulations also permit other NIOSH/MSHA respirators under specified conditions. (See your safety equipment supplier). Engineering or adminstrative controls should be implemented to reduce exposure.

Ventilation: Provide sufficient mechanical (general and/or local exhaust) ventilation to maintain exposure below level of overexposure (from known, suspected or apparent adverse effects).

Protective Gloves: Wear resistant gloves such as: polyvinyl chloride.

Eye Protection: Chemical splash goggles in compliance with OSHA regulations are advised; however, OSHA regulations also permit other type safety glasses. (Consult your safety equipment supplier)

Other Protective Equipment: To prevent repeated or prolonged skin contact, wear impervious clothing and boots.

SECTION VI
SPECIAL PRECAUTIONS OR OTHER COMMENTS

Containers of this material may be hazardou when emptied. Since emptied containers retain product residues (vapor, liquid, and/or solid), all hazard precautions given in this data sheet must be observed.